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REVIEW AND RECOMMENDATIONS FOR THE INTERAGENCY SHIP STRUCTURE C--ETC(U)
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Review and Recommendations for the Interagency Ship Structure Committee's Fiscal 1982 Research Program and Five-Year Research Program Plan

Ship Research Committee

Maritime Transportation Research Board

Commission on Sociotechnical Systems

MARITIME TRANSPORTATION RESEARCH BOARD

Commission on Sociotechnical Systems

National Academy of Sciences -- National Research Council

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REVIEW AND RECOMMENDATIONS for the INTERAGENCY SHIP STRUCTURE COMMITTEE'S FISCAL 1982 RESEARCH PROGRAM and FIVE-YEAR RESEARCH PROGRAM PLAN.

A Report Prepared

by the

SHIP RESEARCH COMMITTEE

of the

NRC

Maritime Transportation Research Board

Commission on Sociotechnical Systems

National Research Council

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NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the Councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the Committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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This report was prepared for the interagency Ship Structure Committee, consisting of representatives from the Military Sealift Command, the U.S. Coast Guard, the Naval Sea Systems Command, the Maritime Administration, the American Bureau of Shipping, and the U.S. Geological Survey, and is submitted to the Commandant, U.S. Coast Guard, under provisions of Contract DOT-CG-80356-A between the National Academy of Sciences and the Commandant, U.S. Coast Guard, acting for the Ship Structure Committee.

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CONTENTS

ABSTRACT

The Ship Research Committee (SRC) of the National Research Council provides technical services covering program recommendations, proposal evaluations, and project advice to the interagency Ship Structure Committee (SSC), composed of representatives from the U.S. Coast Guard, the Naval Sea Systems Command, the Military Sealift Command, the Maritime Administration, the American Bureau of Shipping, and the U.S. Geological Survey. This arrangement requires continuing interaction among the SRC, the SSC, the contracting agency, and the project investigators to assure an effective program to improve marine structures through an extension of knowledge of materials, fabrication methods, static and dynamic loading and response, and methods of analysis and design. This report contains the Ship Research Committee's recommended research program for five years, FY 1981-1985, with 12 specific prospectuses for FY 1982. Also included is a brief review of 24 active and 5 recently completed projects.

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The SHIP STRUCTURE COMMITTEE is constituted to prosecute a research program to improve the hull structures of ships and other marine structures by an extension of knowledge pertaining to design, materials and methods of construction.

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The SHIP STRUCTURE SUBCOMMITTEE acts for the Ship Structure Committee on technical matters by providing technical coordination for the determination of goals and objectives of the program, and by evaluating and interpreting the results in terms of structural design, construciton and operation.

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INTRODUCTION

Organizational and Administrative Matters

Establishment of Committees

Since 1946, the National Research Council's Ship Research Committee (SRC) and its predecessors have been rendering technical services to the interagency Ship Structure Committee (SSC) in developing a continuing research program, sponsored by the SSC and funded collectively by its member agencies, to determine how marine structures can be improved for greater safety and better performance without adverse economic effect.

The SSC was established in 1946 upon recommendation of a Board of Investigation, convened by order of the Secretary of the Navy, to inquire into the design and methods of construction of welded steel merchant vessels. As that investigation was brought to a close, several unfinished studies and a list of worthy items for future investigation remained. The Board of Investigation recommended that a continuing organization be established to formulate and coordinate research in matters pertaining to ship structure. Figure 1 shows the relationship of the various organizational entities involved in the work of the SSC.

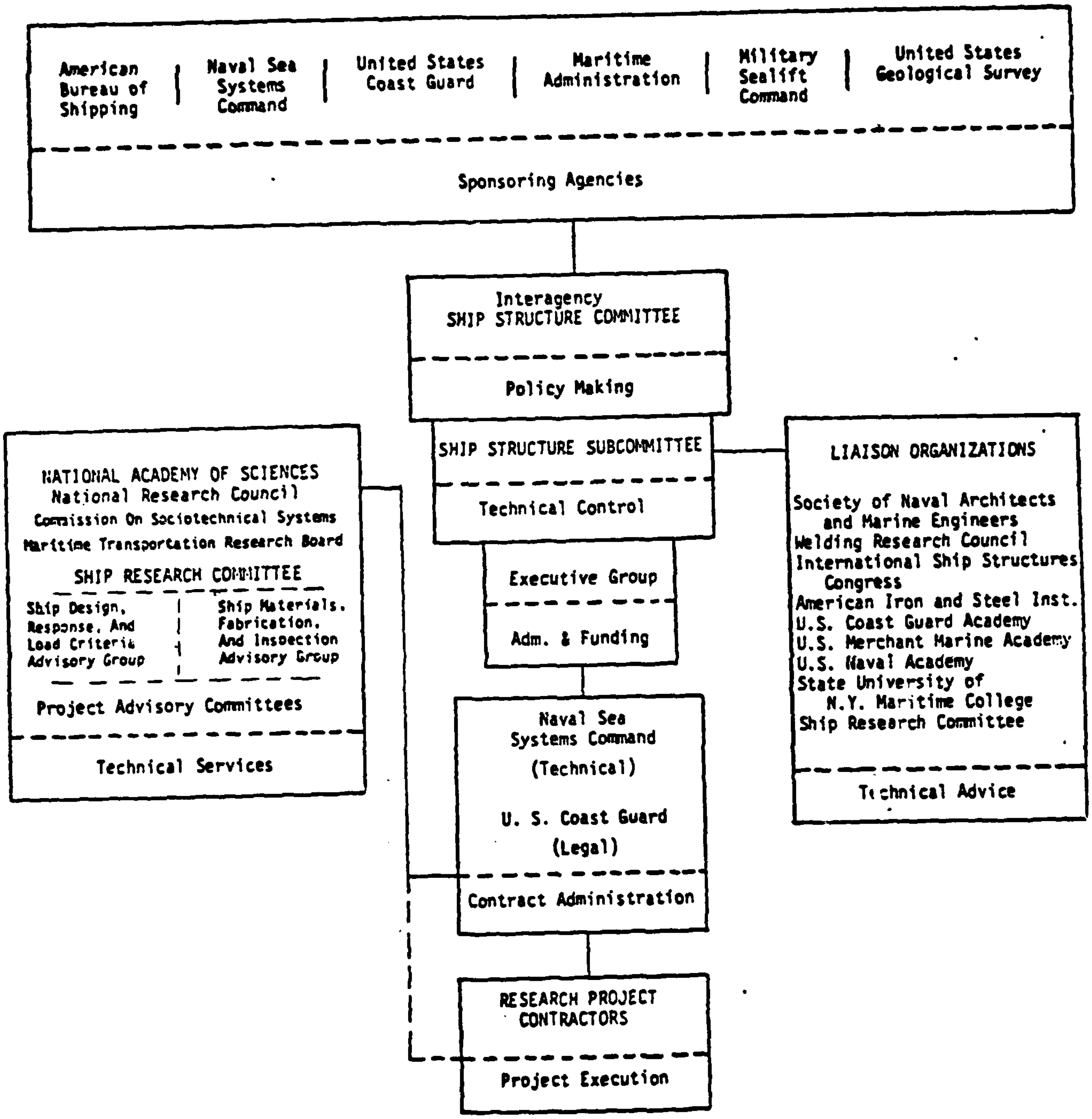

FIGURE 1. SHIP STRUCTURE COMMITTEE ORGANIZATION CHART

Committee Composition and Responsibilities

The SSC is composed of senior officials, one each, from the U.S. Coast Guard, the Naval Sea Systems Command, the Military Sealift Command, the Maritime Administration, the American Bureau of Shipping, and the U.S. Geological Survey.

The SSC formulates policy, approves program plans, and provides financial support through its member agencies for the research program.

A maximum of four representatives from different divisions within each agency meet periodically as a Ship Structure Subcommittee (SSSC) to assure achievement of program goals and to evaluate the results of research projects in terms of structural design, construction, and operation.

Members of the SRC and its advisory groups are selected for their competence and experience in relevant areas from academic, governmental, and industrial sources. The members serve as individuals, contributing personal knowledge and judgement, and not as representatives of organizations where they are employed or with which they may be associated. The SRC's responsibilities to the SSC are to assist in setting technical objectives; define research projects; recommend research priorities; evaluate proposals; review the active projects, including progress and final reports; and prepare summaries of related research work.

Research Program Development

In the past, a September joint meeting of members of the SRC, the SSSC, and the Hull Structure Committee of The Society of Naval

Architects and Marine Engineers (SNAME) was held to review current research needs and suggestions for future research projects. Each agency of the SSC prepared a memorandum describing its discernment of needed research that was provided to all participants in advance of the meeting.

This year's research program development was changed in order to take advantage of the preliminary results of a three-day workshop to develop a long-range research program in ship structures. The workshop was part of the SSC's project SR-1259 initiated in 1979 to develop a marine structures research planning document. Participating in the workshop were representatives from the various agencies, shipbuilders, design offices, universities, and research organizations.

At a September 1980 meeting of the SRC, a number of matters were reviewed. These included the preliminary workshop results, research suggestions from SSC project reports yet to be published, the SSC five-year research program plan, prospectuses not currently funded, joint committee agency suggestions, and the five-year vibration research plan developed from the 1978 Vibration Symposium. This resulted in SRC proposing actions on a total of 59 potential research projects.

A few weeks later at the Fall meeting of the SSC, the SRC presented its preliminary reactions to all of the suggestions and discussed with the SSC project areas for which prospectuses could probably be developed. At this meeting, and subsequent to it, the member agencies of the SSC expressed their preliminary preferences to the SRC.

Project Development

All the suggestions for research projects are carefully studied for applicability to the SSC research program in terms of need, immediacy, program continuity, and likelihood of successful and meaningful completion. A prospectus is drafted by the appropriate SRC Advisory Group for each of the research projects that is considered worthy of SSC support. These are reviewed and ranked by the SRC and included in an annual report to the SSC. The SSC determines which projects will be supported. A Request for Proposal (RFP) is then prepared and issued through the cooperative effort of the Naval Sea Systems Command, which provides technical contract administrative support services, and the U.S. Coast Guard, which handles the actual business of contracting. The RFPs go to research laboratories, universities, shipyards, and other organizations and are advertised in the Commerce Business Daily.

Proposal Evaluation Procedure

An organization interested in doing work submits a proposal and an estimated cost. The USCG Contracting Office removes the cost data and transmits the technical data in the proposal to the SRC for technical evaluation and review.

The SRC Executive Secretary verifies that no SRC or Advisory Group member or affiliated company is represented in the proposals. This important step avoids conflict of interest. The SRC chairman selects an *ad hoc* proposal evaluation committee that generally consists of the Chairmen of the SRC and the pertinent Advisory Group and two or three other members from either the Advisory Group or the SRC.

The proposals are evaluated for the analysis of the problem, the proposed solution, the assessment of the scope of the effort, and the adequacy of the organization and personnel.

After the evaluation committee judges the technical merit of the proposals, ranks them, and comments on any shortcomings, the USCG Contracting Officer forwards the technical evaluation and cost data to the SSC. The SSC considers the proposals together with the technical evaluation and costs and sends its recommendations to the Contracting Officer, who, following routine procurement practices, then awards a contract.

Annual Report Summary

Status and progress of SRC-SSC research activities and SRC recommendations to the SSC for continued and new research to be funded during the ensuing fiscal year are submitted annually.

This, the latest in the series of annual reports, covers research activities during FY 1981, sets forth recommendations for the SSC's FY-1982 research program, and outlines a five-year research planning program.

Five-Year Research Program Plan Development

A continuing program of research in marine structures must be guided by a perception of the directions in which marine activity is moving. The FY-1982 program and the associated five-year plan are aimed at producing programs that will support emerging needs of marine development as best they can now be perceived. The most significant areas of concern for research in the current year and the next four years addressed in the program, namely fracture, vibration, ice

strengthening, fatigue and corrosion are discussed in the following paragraphs.

Fracture

One of the primary objectives in the design of complex structures is the optimization of structural performance consistent with economic considerations. Safety and reliability of each structure must be ensured by considering the proper combination of materials, design, fabrication and inspection. Whether recognized or not, some uncertainty is inherent in most human endeavors; engineering design is no exception. For marine structures, these uncertainties are associated with the randomness of natural phenomena such as storms and waves; with the variability of material strength and workmanship tolerances; with errors (bias as well as uncertainty) in the predictive tools of analysis and design; and with mistakes or omissions in judgement. Except for the latter, probabilistic methods and reliability concepts enable us to deal rationally with these uncertainties, and to assess their consequences. Mistakes or omissions in judgement should be minimized by independent verification of the engineering effort.

Reliability concepts are relevant to all areas of engineering analysis and design--from development of criteria for design to achieve a desired safety index, to quantitative evaluation of the probability of failure by such mechanisms as extreme overload, fatigue, and fracture.

Continuing advances in fracture mechanics offer considerable promise in allowing the accurate prediction of the overall resistance

of a structure to failure by fracture. Perhaps, because it is still an emerging technology, a number of divergent approaches to fracture control have been proposed. These range from a fracture-safe philosophy, which assumes a dynamic running crack, to a temperature-shift approach, which relies on the static-initiation barrier.

Fracture of ship structures might occur by slow sub-critical cracking because of alternating loads acting in the presence (or absence) of an aggressive environment (to be discussed later under fatigue), or due to fast cracking that might occur in a linear-elastic, elastic-plastic, or fully plastic field. In spite of the fact that a better understanding of each of these would be of value in developing fracture-control plans for ships, research on fracture would be most cost effective if it were directed to a study of the type or types of cracking that have caused the largest number of actual ship fractures. At present, there is not enough information available to be able to make a decision on which types of fracture are most damaging. Work should be initiated to develop this information and then analyze these data in light of today's knowledge of fracture mechanics. The result would be the characterization of fracture behavior in structural parameters that can be used directly by designers and engineers.

Readers familiar with the early history of the interagency Ship Structure Committee (circa 1946) are aware that its beginning traces to catastrophic ship fractures. The SRC continues to be aware of the fracture problems and the SSC research program has contributed

to the understanding today of fracture mechanics. The laboratory of experience, ships at sea, is still producing information and data. Recent projects include surveys of actual structural detail experience and reviews on strain rates which indicate little correlation between laboratory-developed fracture-toughness criteria and actual service experience.

A recommended project proposes to reinforce the input of major ship fracture experience in the at-sea laboratory with the current state of fracture-mechanics knowledge; that is, to review past fractures in the light of today's knowledge, and to survey the new and future fracture events as they occur in the same perspective. Ship designs, construction materials, and metallurgical knowledge of fracture mechanics have improved, so it is appropriate to relate actual sea experience to advance understanding of ship fracture mechanisms in order to develop sound criteria for design, material selection, and construction procedures.

Vibration

Vibration problems continue to be a vital concern to ship designers and operators. This area of concern is viewed from, the standpoint of vibratory excitation (propeller-induced periodic forces), transient excitation (slamming, bow-flare impact), and structural response (springing, bending, torsion and whipping). The SSC-SNAME Ship Vibration Symposium held in 1978 focused attention on these matters and also on the consequences of vibration in terms of habitability, structural and machinery damage, and maintenance.

A recommended project proposed as a result of the Symposium is the development of a vibration-control guide. This guide would serve as a tool for those who are experiencing ship vibration problems and who have limited background in the subject. More comprehensive design guidelines are expected as the developments progress.

While slamming occurs more predominantly in moderate to full-form vessels at light forward drafts, LNG carriers, container ships and barge carriers maintain a fairly constant draft and will probably slam only in very severe weather where their speed must be reduced to minimize motion. In this state, a modification of speed or vessel direction is usually enough to minimize slamming and in extreme weather there is usually nothing that can be done to stop it (even design).

By definition, however, the segregated ballast tanker can have a light ballast draft, and many such vessels in the 50,000 - 100,000 DWT class have been built or are being built at this time. This type of vessel with its full form and relatively modest speed cannot afford to materially reduce its speed in moderate-weather ballast passages due to slamming or even for that matter due to wave slap. The SRC, therefore, proposes that such a tanker be selected for a recommended full-scale slamming data collection project.

Ice Strengthening

Development of various activities in the Arctic has increased the need for ships and marine structures that are capable of withstanding the rigors of the ice-bound environment.

Several old problems are made more severe in this service and several new problems are created. Among the old problems is the concern about brittle fracture in cold steel structures, while among the new is the question of how best to construct a marine drilling structure so that it will not be adversely affected by various ice loadings.

Arctic engineering is being enhanced by a number of different activities. The petroleum industry is attacking the problem and can be expected to contribute greatly to both fundamental knowledge and to the practical development of equipment for specific applications. The U.S. Navy and the U.S. Coast Guard have long been involved with ships which are strengthened to withstand ice-created stresses, and the ship classification societies in this country and abroad and ship operators around the world have a similar interest. A growing amount of technical information is being made public on the research and discoveries of these various organizations. The technical program of the 1981 SNAME Spring Meeting in Ottawa will be devoted to Arctic problems.

In an effort to keep abreast of developments and to contribute to advancement in this field, the SSC has nearly completed a project on "Ice Strengthening Criteria for Ships." This study also outlines a long-term continuing research effort in which the SSC may wish to participate. Therefore, as a next step along this line, it is proposed that a project be initiated to study past ship damage caused by ice and to compare the structural performance of existing ships with the rules under which they were constructed.

It is believed that operations in ice will be a rapidly developing maritime field over the next several decades and that it will benefit from properly directed research.

Fatigue

Fatigue behavior of steels and weldments has typically been analyzed in terms of data on nominal stress or strain versus elapsed cycles to failure (S-N) curves. This type of information does not distinguish between crack initiation and propagation. The results are dependent on the applied stress and the size or type of the laboratory test specimens. The SSC has a number of completed and active projects in this area and has a number of active projects utilizing this approach. In addition, data from fatigue studies that have been generated on other structures subject to load reversals, such as bridges, have been placed in the data bank.

The information generated has proven invaluable in the evaluation of the fatigue performance of structural components and details. Although S-N curves have been used with success, they do not necessarily provide needed information for useful life predictions of structures. Hopefully, the concepts of fracture mechanics will prove useful in developing a more rational analysis of fatigue behavior. If so, this method can be used to determine the initiation life of cracks from stress-concentration factors and to evaluate the behavior of propagating cracks, and should, therefore, prove to be a valuable aid to designers in preventing fatigue failures.

There is an extensive effort being expended to develop the necessary information for the formulation of fracture-control

guidelines for all structures. The basic approach is to assume an initial crack size based on the quality of inspection and then calculate the number of cycles required to grow the crack to a critical size for fracture.

The SSC should not only stay abreast of these efforts but should become involved in areas pertinent to ships. One such project being recommended involves an evaluation of the fatigue and fracture characteristics of plate subject to cyclic loading prior to the occurrence of a readily visible crack. Fracture toughness and fatigue behavior are normally evaluated on virgin (previously unstressed) metal. In ships, however, cracks may extend into plate that has been subjected to many cycles of stress below nominal yield. It is not known how fracture and fatigue characteristics of stressed plate compare to those of virgin plate. This should be evaluated and the results factored into the total effort to design and fabricate fit-for-purpose structures.

Corrosion

Data are being collected in domestic and foreign shipyards on the performance of corrosion-control systems. Methods are developed for procedures that will account for life-cycle costs to evaluate the performance and sensitivity of corrosion-control systems. They include full or partial coatings, anodes and the correlations of the above methods with increased metal thickness.

Research is also being undertaken to define and evaluate available technology for assessing the long-life corrosion fatigue behavior of welded joints in sea water. Plans will be developed for

long-term efforts in the field of corrosion fatigue and they will include probabilistic approaches, where variables will be assigned probability-distribution functions.

The principle role of probabilistic methods can be in evaluating the bias and uncertainty associated with the usual deterministic design procedures; and in establishing consistent design loads, safety factors, and nominal strengths (or allowable stresses). They can also be used to optimize the level of inspection (frequency, accuracy and completeness). This would involve tradeoffs between such costs as inspection services, risk to divers, false alarms, and defects missed--versus the benefit of reduced risk of unexpected, premature, structural failure.

Corrosion of the shell plating and weld-seams are a major problem in marine structures. For Arctic structures and ice strengthened ships, abrasion by the ice removes protective coatings so that the bare hull corrodes significantly faster than the coated hulls of conventional ships. Where weld seams are anodic to the plate, they corrode even faster, and require periodic rewelding. Similar problems arise in non-Arctic marine applications for bare steel--e.g., fixed offshore platforms--during lapses in cathodic protection. The selection of the hull steel and welding procedure, process and electrode play a critical role in controlling the adverse impact of corrosion.

An investigation is being recommended to determine whether certain combinations of hull steel and welding are significantly more advantageous in reducing corrosion and whether there are superior

welding procedures and electrodes to reduce corrosion. Information will be compiled regarding weld-seam corrosion, for both the weld-metal and the heat-affected zone.

In another project, it is proposed to compile a data bank to form the basis for information on corrosion rates upon which to formulate a more rational approach for corrosion margins. It is expected this information will include the reduction in strength due to corrosion wastage as well as the reduction in the capability of materials to resist various modes of fracture damage.

Five-Year Research Program Plan

The five-year research planning program depicted in Table I builds on current activities and places them in perspective with contemplated work in various project areas during the next four years, which are classified under the following seven goal areas of the SSC:

Advanced Concepts and Long-Range Planning
Loads Criteria
Response Criteria
Materials Criteria
Fabrication Techniques
Determination of Failure Criteria (Reliability)
Design Methods

Work in each of these areas includes adequate verification procedures to ensure that sound recommendations are made. The thrust is to expand tne existing base of knowledge in each area that will result in design methods, fabrication procedures, and materials for safer and more efficient marine structures.

It is intended that the program be dynamic and flexible so that it can be modified and redirected to be responsive to changing circumstances.

TABLE I

SHIP RESEARCH COMMITTEE'S RECOMMENDATIONS FOR CONTINUING FIVE-YEAR FISCAL RESEARCH PLANNING PROGRAM FOR THE SHIP STRUCTURE COMMITTEE

GOAL AREA: I - ADVANCED CONCEPTS AND LONG-RANGE PLANNING

PROJECT AREA	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985
Overall research planning studies	Attend SR-1259* workshop to develop Agencies' & Societies' present and planned research work.	Conduct joint meeting to develop present and planned research work.			
	Conduct workshop on on-going work on ship motions and wave-induced loads.				
	Examine current marine structural research status (all agencies). Develop an overall out-line to accomplish general objectives.				
	Complete SR-1259 to develop a coordinated plan including specific proposed technical approaches for each section; provide de-tailed references to past & existing work both domestic & foreign, & provide cost estimates & a cost-benefit ratio. (SR-1259)	Review recommenda-tions and discuss at the above joint meet-ing.		(Commence following research plan.	

* (SR-1259) designation refers to projects described in the yellow pages of this report.

TABLE I (Continued)

PROJECT AREA	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985
GOAL AREA: I - ADVANCED CONCEPTS AND LONG-RANGE PLANNING (Continued)					
Conduct Technical Symposium	Begin preparations for 1982 Symposium on Response of Marine Structures to Extreme Loads.	Conduct Symposium.	Review Symposium Results.		
				Begin preparations for 1985 Symposium.	Conduct Symposium.
Advanced & Long-Range Planning of Materials & Their Applications: Concrete	Complete a survey of construction & operating experience of marine concrete structures. Develop the basis for a research program to provide guidance & recommendations to designers & builders of floating structures. (SR-1270).	Evaluate recommendations for follow-on research.	Begin specific projects.	Continue specific research as indicated by previous work.	
Arctic Materials	Examine USGS' program to survey material property data for applications in Arctic conditions.	Review USGS program to determine if feasibile studies should be started.	Undertake new material research relevant to Arctic resource development.	Continue research.	Review results in terms of actual application

TABLE I (Continued)

PROJECT AREA	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985
GOAL AREA: I - ADVANCED CONCEPTS AND LONG-RANGE PLANNING (Continued)					
Cu-Ni Clad Steels		Follow SNAME HS-9 panel's project for the economic analysis and technical awareness of Cu-Ni clad steels.	Consider program to augment the HS-9 work in this area, if warranted.	Initiate and carry out the program.	Continue effort.
Application of Materials for High-performance Marine Structures		Conduct study to identify data requirements and necessary test program to examine material data for high-performance craft. (82-11)	Review 82-11 results and develop prospectus to conduct experimental program to obtain required material data for high-performance craft.	Continue high-performance craft material data gathering.	Complete experimental program and results.
Collisions and Groundings		Develop grounding loads & analysis logic for a computer program. (SR-1272 - 82-4)	Develop grounding loads & analysis computer program.	Develop logic to incorporate dynamic loading.	Expand grounding loads & analysis computer program with dynamic loading capacity.
			Establish feasibility for model simulation of groundings according to various scenarios & associated model experiments.	Investigate the common technologies and engineering analysis applicable to both ship collision and grounding problems.	Investigate interim design proposals to limit grounding damage.
			Develop analytical procedures for low-energy collision & grounding including studies by ship type.	Compare & modify collision & stranding theory.	Develop generalized design guidelines for low-energy collision & energy absorption criteria & parametric studies for various structural configurations.

* (82-00) designation refers to projects recommended in the green pages of this report.

TABLE I (Continued)

GOAL AREA: II - LOADS CRITERIA

PROJECT AREA	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985
Static/Quasi-Static, Thermal, (Diurnal, Cryogenic, Hot) Cargo, Ballast, Fuel, Cargo Distribution, Light Weight of Ship, Ship's Induced Wave, Ice, Impact, Crushing.	Publish SR-1267 report on ship operations, ice histories of navigable waterways for ice loadings on ships & comparison of present ice strengthening requirements of ships.				
		Analyze & correlate available ship hull ice damage with ice conditions and loads. (82-3)	Utilize correlations to develop guidance for ice strengthened scantlings.	Review guidelines and determine if test data are needed.	Carry out test project, if required.
		Monitor SNAME's Ice Symposium in Ottawa, Canada.			
	Develop program to obtain still-water bending moment data for typical ships. (SR-1282)	Review SR-1282 recommendations & develop prospectus to begin program to obtain still-water bending moment data for typical ships.	Conduct data-collection program	Continue data-collection program.	Complete data-collection program and review results.
				Assess interrelationship and non-linearity effects of various load conditions in different parts of the ship structure.	Prepare design load profiles & recommend modifications to Design Criteria.

TABLE I (Continued)

PROJECT AREA	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985
GOAL AREA: II - LOADS CRITERIA (Continued)					
Dynamic Cargo Liquid, Sloshing Dry, Shifting Load, Pumping Problems, Mobile Cargo (Wheeled Vehicles)	Review & correlate current model & full-scale non-LNG liquid slosh data. Conduct model tests to complete correlations for various fill depths, geometry & excitation parameters. (SR-1284)	Evaluate significance of impulsive slosh loads in full-scale liquid tanks. Develop prediction of wall response to impulsive slosh pressure. Recommend design guidelines for tank walls and internals.	Develop general-purpose curves & tables for use in design of liquid cargo tanks.		
	Review Navy design data sheets on wheel loadings.	Develop plan to review & categorize types of shifting cargo loads, & establish priority of dynamic load problems.	Conduct analyses and tests to establish dynamic loads & corresponding structural responses to shifting cargo under typical operational conditions.	Develop curves & tables for ready use in design for dynamic loads due to shifting cargo.	
Wave-Induced Wave Records/Spectra, Local Ship Wave Instrumentation, Slamming, Green Water, Steady State.	Begin developing a method and a representative data bank for design purposes that identifies the simultaneous occurrence of winds, current and directional wave spectra. (SR-1287)	Collect & analyze wave information and develop long-term wave statistics necessary for fatigue failure analysis.	Continue collection and analysis of wave information.	Develop a method to statistically estimate the combined wave-induced bending and torsional loads necessary to perform structural failure analysis.	
	Continue review of USCG Great Lakes project utilizing the wave-height measuring device recommended for slamming.	Develop detailed plan for full-scale slam instrumentation and wavemeter data collection on oceangoing ship, with due consideration for follow on model tests. (82-9)	Conduct full-scale slamming, bow-flare, and green water impact trials to collect data using instrumentation and plan developed under 82-9 .	Analyze impact pressures and velocities and compare them with theoretical results.	Conduct model tests duplicating full-scale tests. Compare results with prototype and theory.

TABLE I (Continued)

PROJECT AREA	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985
		GOAL AREA: II - LOADS CRITERIA (Continued)			
Wave-Induced (Continued)	Initiate SR-1281 to survey and analyze experience of vessels encountering extreme waves.	Review SR-1281 results and determine if additional studies or data gathering is required.	Consider using scratch gages on several ships being routed through oceans that might encounter extreme waves.	Periodically check scratch-gage records to determine if design changes might be needed.	
	Formulate a hydrodynamic model for predicting ship motions and wave loads above and below the still-water line. (SR-1277)	Develop a motions and and distributed loads computer program accounting for hull shape above and below the still-water line. (SR-1277)	Complete SR-1277 and review results.		
			Develop analytical procedure for solving the coupled fluid-structures interaction problem.	Compare analytical results with model or full-scale data.	Modify procedure where required.
			Determine effects of hydrodynamic forces on structural flexibility.		
		GOAL AREA: III - RESPONSE CRITERIA			
Vibrations Analysis & Prediction, Steady State (Springing, Bending, Torsion) Transient, (Whipping), Measurement/Verification.	Organize vibration-related projects, such as full-scale data collection, model tests, developing added mass characteristics, verification of analytical procedures, into a planned program.	Correlate the proposed vibration-related projects program with the long-range planning document from SR-1259.			

TABLE I (Continued)

PROJECT AREA	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985
		GOAL AREA: III - RESPONSE CRITERIA (Continued)			
Vibrations (Continued)	Complete SR-1261 on collecting & evaluating ship structural damping data and preparing a testing program.	Review SR-1261 results and prepare prospectus to obtain full-scale ship damping data.	Obtain full-scale ship vibration damping data.	Conduct model tests, on similar type ship, in air and in water to separate various damping components.	Correlate model and prototype data with theory.
Stress, Deformation Analysis & Prediction, Measurement/Verification, Steady State, Transient, Static Thermal.	Review SR-1275 data from M.V. CORT instrumented for full-scale pressure measurements and compare with ABS computer predictions.	Evaluate SR-1275 results and continue data collection.	Examine second-year of data collection if taken.		
	Complete pressure distribution model tests. Use ABS computer program to calculate pressure distribution corresponding to model tests. (SR-1271)	Evaluate model, full-scale, and computer results for pressure distribution.	Proceed with necessary adjustments to testing techniques or to computer program for oblique seas.	Complete additional model tests in oblique seas.	Review pressure measurement results.
		Develop analytical methods capable of analyzing nonlinear structural responses to random excitations. (82-8)	Test method on models.		
			Consider obtaining load forces from the hull of an ice breaker.	Initiate instrumentation of an ice breaker for hull load measurements and collect data.	Develop response factors by applying analytic techniques to various hull configurations and ice loadings.

TABLE I (Continued)

PROJECT AREA	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985
GOAL AREA: III - RESPONSE CRITERIA (Continued)					
Stress, Deformation (Continued)	Complete SL-7 scratch-gage data collection and reduce data.				
	Complete scratch-gage data evaluation and review guidelines on when to remove gages. (SR-1268)	Consider recommendations to instrument other ships for extreme loads, such as for ice or large waves.			
	Complete evaluating SL-7 research program results and review recommended improvements, broadening or restricting data gathering. (SR-1279)	Review results and consider implementing as modifications to existing full-scale measurement programs.			
	Establish deflection guidelines for ships in relation to main machinery alignment tolerances. (SR-1266)				
	Initiate project to develop procedure to measure shipboard strain rates. (SR-1285)	Complete SR-1285 and pre pare prospectur to begin instrumenting a ship.	Instrument ocean-going ship to obtain strain-rate data. Review applicability to offshore structures.	Analyze full-scale data and compare with fracture toughness data uses. Continue gathering data on another class of ships or an offshore structure.	Consider if changes are to be suggested for fracture criteria, or as a factor in design.

TABLE 1 (Continued)

PROJECT AREA	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985
		GOAL AREA: IV - MATERIALS CRITERIA			
Fracture and Fatigue Control	Investigate fatigue behavior in terms of measured load spectra developed from ship strain measurements and assess the crack retardation effects. (SR-1254)				
	Classify the vulnerability of ship details under cyclic loading using the best available procedure. Conduct experimental work to verify the classification procedure selected and to fill in gaps for details where needed information is not available. (SR-1257)	Review SR-1257 results and consider testing more ship details in formulating a future program. Use the fatigue guidelines and design procedures developed in the selection of ship details in preparing the ship structural details guide in R2-12.	Conduct additional tests as needed.		
	Initiate a program to use long-term corrosion fatigue data in the design of offshore structures and ships. (SR-1276)	Continue SR-1276 and develop a long-term test plan.	Review program, provide an initial guide for a fatigue control plan in offshore structures and ships.	Begin long-term corrosion fatigue tests.	Continue testing.
		Initiate project to determine the amount of damage produced in ship structures by cyclic loading prior to occurrence of visible cracks. (R2-6).	Continue with fracture toughness and crack-growth rate tests on pre-fatigued ship plate.	Review project results.	

TABLE I (Continued)

PROJECT AREA	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985
GOAL AREA: IV - MATERIALS CRITERIA (Continued)					
Fracture and Fatigue Control	Initiate project SR-1288 to review fracture control plans for fixed offshore platforms.	Critically review fracture-control plans for fixed offshore platforms which include materials, properties and designs for increased reliability in extreme marine environments. (SR-1288)	Review results and indicate research in needed areas.	Initiate important projects.	Continue effort.
		Undertake a study of ship fracture mechanisms in light of today's knowledge of fracture mechanics. (82-1).	Examine potential courses for future research and continue evaluation of new fractures.	Review 82-1 results.	
				Review safety analysis of ship structural details against fracture and fatigue failures. Develop reliability-based inspection and maintenance schedules to insure safety against brittle fracture.	Develop an overall fracture-control plan for ships that incorporates both fatigue and fracture behavior of fabricated ship details and a reliability analysis.
				Evaluate full-scale strain-rate shipboard data in light of proposed fracture guidelines.	Modify guidelines, if necessary.

TABLE I (Continued)

PROJECT AREA	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985
GOAL AREA: IV - MATERIALS CRITERIA (Continued)					
Corrosion Control	Complete a survey and life-cycle cost study to identify the most economical corrosion control systems in the existing and projected economic and regulatory climate for internal surfaces in steel tankers. (SR-1269)	Decide on the basis of cost study results, whether or not a more rational approach to corrosion margins is required.	Initiate study or experimental program.	Make recommendations for changes in design methods.	
		Initiate project to develop a data bank for assessing local and overall corrosion on the life of a hull. (82-10)	Continue 82-10.	Complete 82-10 and decide whether or not a more rational approach to corrosion margins is required.	Develop a more rational approach to corrosion margins, if needed, and to assess the most corrosive damage in service.
		Initiate project to develop a guide in selecting the optimal combination of steel and welding to prevent accelerated weld seam corrosion in arctic structures, ice strengthened ships and bare welded steels. (82-7).	Continue long-term laboratory tests.	Continue long-term laboratory tests and complete development of a practical screening test.	Develop guidelines and present results.

TABLE I (Continued)

GOAL AREA V FABRICATION TECHNIQUES

PROJECT AREA	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985
Improved Weld Quality Guides		Develop weld quality levels based on fracture mechanics analysis and consideration of existing fracture and fatigue test data. (82-5).	Review results of 82-5 study and formulate an on going program.	Conduct further research if needed to support fracture-mechanics based weld quality levels.	Review test results and provide guidance for change in quality levels, if required.
	Review Welding Research Council's report on distortion control in aluminum weldments and its applicability to marine structures.				
Underwater Welding	Initiate project to examine performance of underwater and water backed welds. (SR 1283)	Conduct necessary testing and evaluate program.	Review project results		
Design of Welded Ship Details	Review Navy detail manual when completed and current ASTM work underway.	Initiate study to prepare a guide that will assist designers in selecting details that minimize both operational problems and construction costs. (R, 12)	Consider effects of mean stress, material properties, residual weld stresses in predicting the performance of such details in a fatigue environment.	Conduct additional testing to determine effects of the variables where required.	Evaluate results and prepare a revised guide on welded ship details.
Effects of High Deposition Welds on Improved HAZ	Identify critical controls & compositions in the development of improved weldments using high-deposition rate processes and procedures. (SR 1256)	Conduct more detailed metallurgical examination of seven promising steel compositions	Complete metallurgical examination and recommend best composition to use for high heat input welding	Produce full-scale heat of best composition and have different shipyards participate in testing program.	Provide an initial guide for use on high-deposition rate weld processes in ship construction.

TABLE I (Continued)

PROJECT AREA	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985
GOAL AREA VI — DETERMINATION OF FAILURE CRITERIA (RELIABILITY)					
Failure Modes and Safety Analysis	Complete assessment and analysis of major uncertainties in current ship hull design procedures. (SR-1280)	Review results relative to ongoing work on reliability of fixed and floating offshore platforms.	Evaluate reliability in terms of failure probability or safety index for major failure modes of ships and other types of marine structures, designed according to current requirements.	Formulate a consistent reliability-based approach to design of marine structures against specific failure modes, such as overload, fracture and fatigue.	Specialize these criteria to specific applications, e.g., conventional ships and steels; mobile platforms; fixed platforms; advanced structural concepts and materials.
			Initiate project to study successive transfer of load and progressive failure in redundant parallel load path structures, considering such modes as buckling, fatigue, and fracture.	Synthesize results in terms of the influence of various initial imperfections and subsequent damage on reliability, considering the role of structural redundancy.	Review the impact of these findings on the choice of inspection criteria, specialized to various types of marine structures.
In-Service Monitoring	Develop philosophical structural inspection guidelines (SR-1289)	Review results relative to ongoing work on inspection of fixed and floating offshore platforms. (82-1)	Review various methods for in-service inspection in terms of their cost-effectiveness for various classes of marine structures.	Review formats for implementing in-service inspection, as well as making rational choices regarding repair, abandonment, or alternative protective measures.	Integrate these results with those from project areas of Failure Modes and Safety Analysis.
GOAL AREA VII — DESIGN METHODS					
Design Procedures: Efficiency, Economics, Optimization, Test and Evaluation, Preliminary Design			Consider need to develop procedure for predicting transverse plane motions and transverse and torsional loads.	Fabricate large-scale hull girder model and test to failure, measuring stresses and deformations and comparing with calculations.	Evaluate possibility of using ultimate strength in hull girder design roles.

TABLE 1 (Continued)

GOAL AREA VII DESIGN METHODS (Continued)

PROJECT AREA	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985
Design Procedures [illegible]				Consider generalizing the analytical model of ship-ice interaction to account for high triaxial crushing strengths, high strain rates, and non-constant load distribution.	Develop model and support results with full-scale data.
			Develop preliminary design procedures for ends of ships to avoid vibration and slamming damage	Verify the preliminary design procedures for ends of ships.	
	Complete supplementary monograph to [illegible] NAVAL DESIGN [illegible]				
	[illegible] welds for [illegible]	Evaluate fillet weld [illegible] results and suggest new guidelines			
[illegible]		Develop a vibration [illegible] guide for [illegible] operator	Review guide and develop method to expand and provide a more comprehensive guide	Continue work in preparing a comprehensive guide.	Continue developing guide elements.

FISCAL 1982 PROJECT RECOMMENDATIONS

Table II lists the projects proposed for the Fiscal Year 1982 Program in priority order, based on the composite judgement of the SRC membership, after further consideration of the recommendations of the Advisory Groups. Prospectuses for these projects are presented in the same priority order.

As in past years, more projects are included than are likely to be funded with the anticipated support. However, the possibility of greater support, the need of the SSC for a reasonable number of projects from which to select, and the possibility that some projects not initiated in Fiscal Year 1982 could well be included in the program for the following year, suggest that the preparation of the additional prospectuses is a useful service.

The man-hour figures are intended to indicate the approximate level of effort (cost) that is estimated to be required for completion of the project.

TABLE II -RECOMMENDED PROJECTS FOR THE 1982 FISCAL YEAR

PRIORITY	PROJECT TITLE	PAGE
82-1	Ship Fracture Mechanisms Investigation	33
82-2	Guide for Shipboard Vibration Control	36
82-3	Conduct Analysis of Hull Ice Damage	38
82-4	Computer-Aided Procedure for Calculating Grounded Ship Responses	41
82-5	Weld Quality Levels for Ship Structural Integrity	44
82-6	Structural Behavior After Fatigue	46
82-7	Selection of Steel and Welding Procedures to Prevent Accelerated Weld Seam Corrosion	48
82-8	Analysis of the Nonlinear Response of Marine Structures Subjected to Random Excitation	50
82-9	Full-Scale Slam Instrumentation and Wavemeter Data Collection	54
82-10	Corrosion Experience Data Bank	57
82-11	Material Requirements for High-Performance Craft	59
82-12	Improved Design of Ship Structural Details	62

SHIP FRACTURE MECHANISMS INVESTIGATION SRC PRIORITY 82-1

Long-Range Goal Area: Materials Criteria

OBJECTIVE

To examine current and future ship fractures over a period of years, to examine past ship fractures in the light of present understanding, and to catalog and assess the types of fractures that occur in ship structures.

BACKGROUND

Investigation of welded ship failures during World War II led to an early understanding of brittle fracture, in terms of Charpy values which characterized source plates, versus through plates, versus arrest plates--as well as the role of design details in providing crack initiation sites. Since then, the notch toughness of ship steels has been upgraded, such that large cracks are now often detected visually before reaching the stage of catastrophic fracture.

Significant advances in the understanding of fracture mechanics have occurred in the intervening decades. Surprisingly, these have resulted in divergent approaches to fracture control being proposed, ranging from the fracture-safe philosophy, which assumes a dynamic running crack, to temperature-shift criteria, which rely on the static initiation barrier (i.e. increased toughness levels under quasi-static strain rates).

Fracture of ship structures might occur by slow, sub-critical cracking because of alternating loads acting in the presence or absence of an agressive environment, or due to fast cracking that might occur in a linear elastic, elastic-plastic or fully plastic

field. In spite of the fact that a better understanding of each of these would be of value in developing fracture-control plans for ships, research on fracture would be most cost effective if it were directed to a study of the type or types of cracking that have made the largest contribution to actual ship failures. At present, there is not enough information available to be able to make a decision on which types of fracture are most damaging. This program is being proposed to examine cracks in ships to develop this information.

WORK SCOPE

The following tasks are considered essential to the study:

1. Survey and review marine structure fractures, the early ones as well as recent experiences, in light of today's knowledge of fracture mechanics. This is to be performed in two ways:

A. Review available reports

B. Examine ship fracture incidents when they are reported, as directed by the Secretary, Ship Structure Committee, and then as outlined in (a) through (e) below:

a. Find, describe, catalogue, preserve, and store data on the origin and other important aspects of all cracks, whenever possible. The location of the origin should be described with respect to the structural and fabrication details of the ship in the area of the crack. The cause of the origin should be determined, e.g. weld defect, arc strike, notch, plastically deformed region, weld heat affected zone, etc.

b. Determine whether or not fatigue crack extension occurred in the vicinity of the origin, if so, how much. Determine whether or not all of the crack was due to fatigue.

c. Determine whether the crack extended in a cleavage or tearing mode. Was there measurable permanent deformation, either locally or generally, associated with the crack?

d. Determine whether the crack arrested? If so, was the reason for arrest apparent?

e. Augment all observations with photographs and fractographic analysis, where possible.

2. Compare serious failures with the numerous failures documented in SSC-272, "In-Service Performances of Structural Details" and SSC 294, "Further Survey of In-Service Performance of Structural Details."

3. Comment on the relevance of the various approaches to fracture control now being proposed by comparing the consequences of failure with the mechanisms at work.

4. Examine potential courses for future research in light of the foregoing--including, if appropriate, detailed proposals for ongoing survey and review of hull failures.

<u>MAN HOURS</u>

First year	-	1500
Second year	-	1000
Third year	-	1000

GUIDE FOR SHIPBOARD VIBRATION CONTROL SRC Priority 82-2

Long-Range Goal Area: Design Methods

OBJECTIVE

The objective of this project is to develop a vibration-control guide which will serve as a useful tool in the hands of ship operators, shipyards, and others who must deal with ship vibration problems but who have limited knowledge and experience in the field.

BACKGROUND

It is envisioned that various portions of the work described in Reference 1 will be undertaken over the years by SNAME, by the Ship Structure Committee, Maritime Administration and by others. For the present project it is desired to publish a Guide for Shipboard Vibration Control as described in Section III E of the referenced report. The description of the Guide, as given in the report, is as follows:

"This Guide would gather in one document the most recent rules of thumb for vibration control on ships for use by operators, shipyards, and others with limited experience in the field of vibration and would act as a catalyst in generating interest in vibration control, pending the development of a more comprehensive design guide."

WORK SCOPE

The following tasks are considered essential to this study:

1. Become familiar with the literature on the subject of ship vibration.

2. Prepare an outline and a mock-up of the subject guide which shall include but not be limited to the following items:

Nomenclature

Design "Rules of Thumb"

Methods for measuring vibration

Criteria of acceptable levels of vibration

Suggestions as to assessing the gravity of the problem and the sources of assistance to the solution

Examples of vibration problems which have occured and methods used to resolve them.

3. Prepare the final guide.

REFERENCE

1. A Proposed Five-Year Ship Vibration Research Program, by E.F. Noonan and W.A. Wood, August 15, 1980.

MAN-HOURS

1000

CONDUCT ANALYSIS OF HULL ICE DAMAGE SRC Priority 82-3

Long-Range Goal Area: Load Criteria

OBJECTIVE

The objective is to analyze available ship hull ice damage, correlate it with ice conditions and loads that caused the damage, and later use this information to develop improved guidance for ice strengthened scantlings.

BACKGROUND

Several analytical and semi-empirical methods are used and others have been proposed for structural design of ships operating in ice. In general, the various designated levels of ice strengthening in use are not related specifically to the severity of the ice conditions to be encountered nor to zones and seasons in the manner of application of load lines. In many instances, strengthening for operation in ice is accomplished by proportional increases in the strength of plating and framing members which involves the tacit assumption that ice loads are related to longitudinal and transverse strength requirements and hydrostatic loads. Other regulations now in use involve approximations of actual ice pressures on the ship structure on the basis of anticipated ice thickness, ship size, horsepower or other parameters. Some studies proposed design criteria and have compared them to known design bases used for a number of icebreakers and other ships. They have further identified a number of these designs with known ice caused structural failures. However, no systematic analyses have been carried out of specific hull ice damage cases with known and assumed ice load that caused the damage.

In this study, it is proposed to analyze the damage and correlate it with the best known information regarding ice conditions, thickness and strength that caused it. Following this step, specific ice strengthening criteria suitable for adoption in the design of vessels operating in ice would be developed.

WORK SCOPE

Phase I

The following tasks shall be included in the study:

1. Review past damage in hull structures that occurred during operations in various ice conditions.

2. Classify damage by location on hull (bow, side, bottom etc.) by extent of damage, and type and mechanics of damage such as:

- frames
- longitudinals
- deformation
- fracture
- brittle fracture

3. Classify damage by ice conditions and type of ice such as level ice, one-year ice, multi-year ice, strength of ice, temperature, etc.

4. Classify damage by type of impact as affected by different operating situations such as speed, continuous ice breaking mode, ramming mode, impact by bergy bits, operation in level ice or going through ridges, etc.

5. Develop semi-empirical techniques which will enable the correlation of mode of failure, ice conditions and best known impact mode, etc., based on several available failure cases above.

6. Carry out correlation calculations and analysis of the available useful data, so that this information could be later used to develop ice strengthening rationale.

Phase II

If findings in Phase I are promising, proceed with Phase II, which will include:

1. Compare semi-empirical techniques developed in Phase I with load factors developed in SSC Project SR-1267," Ice Strengthening Criteria for Ships" and with various other criteria.

2. Propose improved guidance for ice strengthened scantlings.

MAN-HOURS

First year - 2500 - Phase I

Second year - 2000 - Phase II

COMPUTER-AIDED PROCEDURE FOR CALCULATING GROUNDED SHIP RESPONSES

SRC Priority 82-4

Long-Range Goal Area: Advanced Concepts and Long-Range Planning

OBJECTIVE

The objective of the project is to design the logic for a computer program which will aid in the assessment of damage, stability, and survivability of grounded tank ships, including LNG carriers.

BACKGROUND

Ship groundings are a significant source of marine environmental damage and account for a large percentage of ship structural failures worldwide. In a grounding, the ship may be damaged so severely that its ability to return to a shipyard, assuming it could be refloated, is questionable. If it is firmly grounded or if the forces of wind, waves, or currents cause it to broach, it may be destroyed or fail with serious damage to the environment and possible loss of life. Current state-of-the-art techniques are sometimes successful if the salvor has time, equipment, and fair weather available as well as a generous portion of luck or providential intercession.

Information is needed to assess the state of damage to the ship, the likelihood of further damage, the possibility and course of action necessary to refloat the vessel, and the effect of various salvage actions on the strength and stability of the vessel. The less severe grounding situations, in which the ship is only locally affected with a large margin of damage stability remaining, may lend

themselves to a computerized approach to analysis. Such a program could be used as an aid to the salvage team to determine the best course of action during an actual casualty and as an after-the-fact analysis tool to determine future design parameters and salvage methods.

WORK SCOPE

The following tasks constitute the major efforts to be accomplished under this project:

1. Review current literature on the subject of grounding and stranding. Reference 1 contains much of the current literature in its list of references.

2. Interview marine salvage organizations with experience in salvaging grounded vessels to determine the state-of-the-art of salvage analysis and their views about needed computer capability.

3. Analyze the factors that affect the ship during transfer from the fully buoyant to the grounded condition and the factors that affect the survivability of the ship.

4. Analyze the factors that affect the damaged ship during transfer from a grounded condition to fully buoyant.

5. Inputs to the program should include but not be limited to the following:

* Hydrostatic properties of the ship including compartments open to the sea.

* Ship's bonjean curves, longitudinal weight distribution, intact stability and deviations from design form characteristics, such as, hogging, sagging, flooded compartments and local damage.

* Ship Hull Characteristic Program, (SHCP).

* Flexibility of the ship, including longitudinal bending and local stiffness.

* Sea bottom support characteristics based on the type of sea bottom, i.e., solid rock, gravel, sand, mud.

6. The program should provide outputs that include but are not limited to:

* Evaluation of the stability of the ship.

* Evaluation of the loads, stresses, and deflections of the ship.

* Evaluation of the effect of modifying the weights, buoyancy, damaged compartments, extent of bottom support, and other factors that may not be precisely known or that can be modified to improve survivability of the ship.

7. Prepare a program flow chart.

8. Provide an outline of use based on specific examples of two or three actual casualties.

REFERENCE

1. N. Jones, A Literature Survey on the Collision and Grounding Protection of Ships, SSC-283, 1979.

MAN-HOURS

2000

WELD QUALITY LEVELS FOR SHIP STRUCTURAL INTEGRITY SRC Priority 82-5

Long-Range Goal Area: Fabrication Techniques

OBJECTIVE

The objective is to develop specific proposals for weld quality based on fracture mechanics analysis and consideration of existing fracture and fatigue test data obtained for weld joints with defects.

BACKGROUND

Weld quality standards are generally established on the basis of workmanship considerations and characteristics of the nondestructive inspection (NDI) methods being used. The acceptance limits are set such that a qualified welder using the appropriate procedures and equipment can consistantly meet the quality standards. Service experience demonstrates that these standards result in welds of good long-term structural integrity. However, in many cases these quality standards bear no relationship to defect-size limits needed to assure structural integrity. If defect tolerances could be relaxed without adversely affecting the strength and durabiity of the ship, considerble cost savings could result through the use of more efficient procedures and by eliminating unnecessary repairs.

Over the past decade, considerable progress has been made in technologies used to establish rational weld quality standards: e.g., fracture mechanics, NDI, and loads and stress analysis. The Ship Structure Committee has contributed to this knowledge through studies of fatigue and fracture behavior of ship steels, ship loads, response and stress analysis and NDI of ship steel weldments. This extensive

body of knowledge needs to be applied to a reconsideration of allowable defect sizes in welds.

WORK SCOPE

The following tasks are considered essential to the study:

1. Summarize the existing weld quality standards in terms of allowable size for each type of defect, as a function of location in the ship and type of inspection employed.

2. Conduct fracture mechanics parameter studies using a fatigue stress spectrum and maximum credible stresses based on SL-7 and other ship loads data banks, fatigue crack-growth data (e.g. report SSC-251, "A Study of Subcritical Crack Growth in Ship Steels"), and fracture toughness data (e.g. SSC-275, " The Effect of Strain Rate on the Toughness of Ship Steels," and SSC-276, "Fracture Behavior Characterization of Ship Steels and Weldments"). The proposal must outline the rationale to be followed here.

3. Review and summarize available information on the influence of weld defects on fatigue and fracture behavior of ship steel weldments, including weld metal and parent steel. This summary shall be sufficiently detailed so as to fully support any recommended criteria.

4. Develop specific proposals for an alternative set of weld quality definitions based on the information of steps 1, 2, and 3.

5. Compare the alternative definitions with current requirements.

MAN-HOURS

2000

STRUCTURAL BEHAVIOR AFTER FATIGUE SRC Priority 82-6

Long-Range Goal Area: Materials Criteria

OBJECTIVES

The objective of this study is to determine the amount of damage produced in ship structures by cyclic loading prior to the occurrence of readily visible cracks.

BACKGROUND

Damage tolerance is normally measured, either in terms of fatigue crack growth rates or fracture toughness, by conducting laboratory tests on virgin (i.e., previously unstressed) metals. For structures in service, however, cracks may extend into metal sections that were previously subjected to many cycles of stress below nominal yield. This might be particularly important in structures which subsequently experience fatigue cracking. Consider, for example, a section of plating containing a welded-on stiffener. Such a section might fail due to cracks that initiate in fatigue near the stiffener, and propagate into the plate, either by fatigue or fast cracking. In this case, if the plate had been damaged by prior cyclic loading, data collected on virgin material could be non-conservative. The purpose of this program is to measure the magnitude of such prior damage.

WORK SCOPE

The following tasks are considered essential to this project:

1. Conduct both fracture toughness and crack-growth-rate tests on pre-fatigued ABS grade CS or D ship plate and control specimens.

2. Measure prior damage in terms of changes in both fracture toughness and crack-growth rate, i.e., $da/dN = F(\Delta K)$.

MAN-HOURS

2500

SELECTION OF STEEL AND WELDING PROCEDURE TO PREVENT ACCELERATED WELD SEAM CORROSION

SRC Priority 82-7

Long-Range Goal Area: Materials Criteria

OBJECTIVES

The objectives of this project are to develop guidance for designers that will assist in preventing accelerated weld seam corrosion in marine structures through the selection of the optimal combination of steel and welding procedure and the development of a practical screening test that will relate to long-term performance.

BACKGROUND

Corrosion of the shell plating and weld seam is a major problem in marine structures. Where weld seams are anodic to the plate, they corrode even faster, and require periodic rewelding. For Arctic structures and ice strengthened ships, abrasion from the ice removes protective coatings so that the bare hull corrodes significantly faster than the coated hulls of conventional ships. For bare steel marine applications--e.g. fixed offshore platforms--during lapses in cathodic protection, the problem is also significant. The selection of the hull steel and welding procedure, process and electrode play a critical role in controlling the adverse impact of such corrosion.

Many questions remain unanswered. Are certain combinations of hull steel and welding significantly more advantageous in reducing corrosion and maintenance costs? Are there new, superior welding procedures, processes or electrodes that can be used? How can the selection of hull steel and welding be made so that tradeoffs between

strength, weight, cost, fabrication, corrosion and hull maintenance are properly considered?

WORK SCOPE

The following tasks are considered essential in meeting the objectives:

1. Compile available information on weld seam corrosion, both weld metal and heat-affected zone.

2. Use long-term tests and practical experience to evaluate several currently used combinations, including the effect of heat-to-heat variations in the steels, job-to-job variations in welding variables, and effect of periodic abrasion.

3. Select or develop a practical screening test which can evaluate the corrosion of plating and weld seams of hull steel/welding procedure combinations. Compare this to long-term results from the above tests.

4. Identify the tradeoffs other than corrosion that should influence the selection of the hull steel and welding procedures.

5. Identify new or likely future developments in hull materials, welding, and protective coatings, which may influence the weld seam corrosion problem.

6. [illegible]elop criteria that will guide a designer towards selecting the opt[illegible]al hull steel and welding, all tradeoffs considered.

MAN-HOURS

2000 - 1st year

1000 - 2nd year

1000 - 3rd year

2000 - 4th year

ANALYSIS OF THE NONLINEAR RESPONSE OF MARINE STRUCTURES SUBJECTED TO RANDOM EXCITATION

SRC Priority 82-8

Long-Range Goal Area: Response Criteria

OBJECTIVE

To survey available approaches for analyzing nonlinear response of marine structures under random excitation, and to provide guidelines for a probabilistic approach to the analysis and statistical criteria for interpreting results in a consistent manner.

BACKGROUND

Ships and marine structures are subjected to random excitation by environmental elements, and there is a need for analyzing their response from a probabilistic approach. Existing formulations are generally applicable only to linear systems and the conditions for superposition must be valid. For the nonlinear state, equivalent methods of analysis are not as well developed, nor are criteria for evaluating the results.

Nonlinearities may arise in both the loading and response of marine structures, for example,

1. Nonlinear drag force parameters, such as velocity-squared and relative motion

2. Free surface effects such as member immersion/emergence, deck overflooding and slamming

3. Large displacement in compliant structures, marine risers, and catenary moorings

4. Nonlinear lift forces

5. Material nonlinearities, such as plasticity and creep

6. Geometric nonlinearities, such as postbuckling and large deflection

7. Soil-structure interaction in bottom-supported marine structures

8. Hydroelastic response, such as vortex shedding and strumming.

The need for considering nonlinear effects in the extremes of loading and response may be regarded as an integral part of a realistic ultimate strength and reliability evaluation, which must deal with all failure modes, even though the expected behavior may be more-or-less linear under normal conditions. Nonlinear time-domain dynamic-analysis computer programs have been developed to handle man· of these problems. Some of these are specialized to a particu.ar type of structure and loading. Even so, they are always complex and expensive to run; thus, some approach for reducing the complexity and time span covered by detailed analysis is generally taken. Approaches in use include, among others:

1. Selection of design wave based on statistics of the sea state (e.g. Longuet-Higgins), followed by deterministic analysis for this wave.

2. Conditional random wave simulation of a selected extreme event, based on recorded wave profile and hindcast directional spectrum.

3. Selection of one or more design segments of a random sea, based on full-storm (or voyage) duration screening analysis of a

simplified representation of the structure, followed by detailed analysis for the selected random wave time segments.

4. Random analysis for a representative time period followed by extrapolation to the extreme response using non-Gaussian statistics.

5. Nonlinear analysis in regular waves to establish transfer functions (which may vary with sea state) to be used in subsequent linearized analysis.

6. Analysis of a reduced model by one of the foregoing approaches, followed by application of the extreme forces to a more detailed model.

For most of these approaches, a statistical interpretation of the results is required; yet criteria for doing this are not well established. Some approaches yield variable results from multiple trails, and different approaches appear to yield inconsistent answers. Guidelines for selecting rational approaches and calibrating their results in terms of reliability are needed.

WORK SCOPE

The proposed project is to be primarily a philosophical/mathematical study. The following tasks are considered essential in meeting the objective:

1. Review the types of nonlinear behavior of interest for various classes of marine structures, together with the generic types of nonlinear physical models with which they are analyzed.

2. Describe the probabilistic basis of selection of design load and response for structures.

3. Evaluate the various probabilistic, reliability and statistical approaches which may be taken for performing and interpreting nonlinear analysis, in terms of:

a) Their suitability for the various physical problems, available analytical models, and cost constraints

b) Their probabilistic interpretation, in terms of consistency with item (2) and with each other.

4. Write an interpretive report which covers the foregoing items, as well as:

a) Guidelines for selecting type of analytical model, approaching the analysis, and interpreting the results.

b) Recommendations for further research.

MAN-HOURS

1000

FULL-SCALE SLAM INSTRUMENTATION AND WAVEMETER DATA COLLECTION

SRC Priority 82-9

Long-Range Goal Area: Loads Criteria

OBJECTIVE

The objective of this project is to instrument a particular vessel with the intent to correlate the recorded slam data with model and analytical predictions for this particular vessel.

BACKGROUND

Most previous ship instrumentation programs have been directed primarily at measuring midship bending stresses. Programs such as the experiments conducted on the WOLVERINE STATE where pressure transducers were placed in the forward part of the hull bottom did not correlate the data received with analytical or model test predictions.

In addition, one vital piece of information that has been missing from the previous programs has been the relative vertical velocity between the ship's bottom and the water surface at the time that impact occurs. The relative vertical velocity has been shown to be a controlling factor in slam severity.

WORK SCOPE

The following tasks outline the scope of the work which should be considered:

1. Select a base ship design of current interest which has a history of slamming occurrences and possibly damage. Obtain permission for the instrumentation and use of the ship. The SSC and USCG are available to assist in making arrangments with the owner.

2. Design and develop a refined instrumentation system that will obtain data completely usable in the model and analytical analysis to follow using SSC-274 "Development of an Instrumentation Package to Record Full-Scale Ship Slam Data" and SSC Project SR-1275, "Full-Scale Pressure Distribution Measurements of M/V S.J. CORT" as a base. This instrumentation should measure and record a number of phenomena, including relative vertical velocity, hydrodynamic pressure, bottom plating strains and strain rates at various locations, vertical accelerations, and wave data. The instrumentation should also be configured such that the onset of slamming could be predicted and such that the instrumentation signals would be recorded only while slamming is occurring. Sufficient back-up modes are to be developed so that the failure or lack of performance of one component of instrumentation will not detract from the usefulness of the data collected. Consider processing as much of the data on site as possible.

This work should be done with the collaboration of a representative of a model tank, an analytical investigator who is familiar with the state of ship slamming research, and the instrumentation contractor. The scope of the project requires the consultation of the analytical investigator and the experimenter in all phases in order to ensure the acquisition of appropriate data for future correlation.

3. Instrument the selected vessel utilizing an initial manned period to debug the equipment and to train the ship's crew in the operation of the instrumentation as a back-up in case of failure

of the automatic recording feature. Provide a report documenting the system's operation and sufficient data analysis to demonstrate the adequacy of the data quality.

4. Continue to review the data quality and format with the analytical investigator as data are received.

5. Prepare the data and all supporting documentation for future analysis and interpretation.

MAN-HOURS

5000 over 4 years

Phase I - Instrumentation Development

Phase II - Installation & Debugging

Phase III - Data Collection

CORROSION EXPERIENCE DATA BANK SRC Priority 82-10

Long-Range Goal Area: Design Methods

OBJECTIVE

The objective of this project is to develop a data bank of corrosion rates upon which to base a more rational approach for corrosion margins.

BACKGROUND

Corrosion is a major factor contributing to the ultimate failure of structure in a marine environment. The principal effects of corrosion on structural failure include the reduction in strength due to corrosion wastage as well as the reduction in the capability of materials to resist various modes of fracture damage. Individual searches through files establish statistical rates of corrosion wastage for ships operating in salt water environments; however, a larger statistical data base is required to establish the mean value and standard deviation of the corrosion rates needed for reliabilty studies.

Significant benefits could be realized if replacement of a structure could be deferred and life of the structure extended through better understanding of interaction between state of corrosion and residual strength. Improved methods of predicting failure due to corrosion could result in averting such failures.

WORK SCOPE

The contractor shall perform the following tasks:

1. Review the work done under project SR 1269, "Internal Corrosion and Corrosion Control Alternatives"

2. Review other sources of information from ship owners and operators, U.S. Coast Guard and similar international bodies as well as various appropriate industrial and academic institutions. The review should include general corrosion versus pitting, base metal, weld metal, and heat-affected zone, crevice, positions, ship's service, etc.

3. Analyze results of corrosion experience and other available data on corrosion wastage and develop a statistical base.

4. Prepare a report to present the results of the study and, in particular, make detailed recommendations on the basis of the results relating to whether or not a more rational approach to corrosion margins can be developed.

MAN-HOURS

2000 - 3-year period

MATERIAL REQUIREMENTS FOR HIGH-PERFORMANCE CRAFT

SRC Priority 82-11

Long-Range Goal Area: Advanced Concepts and Long-Range Planning

OBJECTIVES

The objectives of the study are to determine material data requirements for use of the marine vehicle structural designer and to recommend a characterization program for the selected materials.

BACKGROUND

In the marine industry, there is a developing interest in reducing weight in marine vehicle structure and a corresponding interest in the use of structural materials of higher strength to weight ratio than conventional steels. Interest in their application includes a) displacement hulls, where high-strength steels offer benefits of increased payload which are modest but nevertheless significant over the life of the craft; b) crew boats and patrol craft with conventional planing hulls, where aluminum and composite materials, effectively used, offer reduced weight for increased speed and payload; c) hydrofoils, where high strength steels and titanium alloys are essential in the foil systems, and d) surface-effect ships and air-cushion vehicles where aluminum alloys and composites in smaller craft and probably high-strength steels in large craft are essential to payload and speed; hence, their economic or military feasibility.

Materials of interest include high-yield-strength steels, aluminum alloys, stainless steels, titanium alloys and, in a more limited way, new material forms such as composites, sandwich construction, etc.

Most of these materials are a carryover from the aerospace industry. In the shipyards, however, more emphasis is placed on weldability, corrosion resistance, and heavier sections and less emphasis on quality control. As a consequence, the alloys used in the aerospace industry, and hence the extensive material characterization background built up by this industry for aircraft and space vehicle applications, are of limited use. There is, indeed, a great need of fatigue and fracture data for the particular alloys and material forms of interest to the marine industry. These include the effects of welding and joining, the effects of the marine environment, the effects of processing and inspection variables and the effects of local geometry of joining details.

WORK SCOPE

The following tasks are considered necessary to meet the objectives:

1. Selectively contact companies and agencies involved in development of high-performance marine craft to determine applications, resulting requirements imposed on structural materials, materials in use and the rationale behind their selection, and material characterization data required for more effective material application. Include in the consideration high-performance displacement vessels, SWATH (small water-plane twin hull) ships, air-cushion vehicles, surface-effect ships and hyrodofoils. In particular, obtain the point of view of designers, who will use the material data, on the required characterization, in addition to the views of material specialists.

2. Review materials and their availability; examine strengths and weaknesses relative to requirements, and select two or three materials of potentially wide application for high-performance marine craft. Include in the consideration, as a minimum, the high-yield steels, the high-strength, precipitation-hardened, stainless steels, titanium alloys, aluminum alloys suitable for marine applications, fiberglass and composites.

3. Define characterization data required for the materials of interests. Define required material test programs including both parent material and joined and fabricated assemblies. Include in the parameters to be considered the effects of environment, processing and joining, nondestructive inspection, geometric details, etc.

4. Prepare a report to represent the results of the study and, in particular, make detailed recommendations for material-characterization programs, i.e. which tests are needed for which materials.

MAN-HOURS

1500

IMPROVED DESIGN OF SHIP STRUCTURAL DETAILS SRC Priority 82-12

Long-Range Goal Area: Design Methods

OBJECTIVE

The objective of the study is to utilize the extensive background data assembled on ship structural details, to prepare a guide that will assist designers in the selection of optimum details to minimize operational problems and construction costs.

BACKGROUND

Ship structural details are important because

a) Their layout and fabrication represent a sizeable fraction of hull construction costs.

b) Details are often the source of cracks and local failure which can lead to serious damage to the hull girder.

c) The trend towards decreasing ship hull scantlings has the potential of increasing the frequency and seriousness of cracks and failures at details.

d) Analysis of structural details has been neglected, partly because of large numbers of configurations, functions, etc.

Partly in response to this situation, the Ship Structure Committee has supported a series of four studies of ship construction details, the results of which are reported in References 1, 2, 3 and 4.

The first study, Reference 1, was an extensive review of ship structural details in which current practice was reported, with descriptions of about 160 details. The study also described damage induced by poor design and fabrication of details, the literature on analysis of details was reviewed, and proposals for a fatigue

criterion which would support the analysis of structural details, were made.

Reference 2 surveys the structural details of approximately fifty different ships, classifying these details into twelve families. Failures in these details were described and causes, such as design, fabrication, maintenance and operation, were postulated, as an aid to designers.

Reference 3 reports on a continuation of the program described in Reference 2, in which an additional 36 ships were surveyed. The results were combined with the results of Reference 2 to provide data on failure of details for use by design and repair offices.

Reference 4 is the most recent continuing project to characterize the fatigue of fabricated ship details. This program includes assembly of fatigue information for a large number of structural members, joints and details; a selection of details which, in service, have exhibited fatigue problems; a compilation of ship loading histories; and an examination of ship structure fatigue criteria. The program will lead to the development of fatigue design criteria for ship details, and an experimental program will be conducted to provide data.

All of this work has provided a wealth of background data on operational experience with a large variety of structural details. From these data, it is now appropriate to develop a design guide to assist designers with the selection of details for all areas of the ship structure, and which will minimize problems and construction costs.

WORK SCOPE

The following tasks are considered necessary to meet the objectives:-

1) Review the work reported in References 1 thru 4. Contact MARAD and DTNSRDC; review similar studies conducted by these agencies and consolidate all information.

2) Extract, for each family of details, those details which have proven satisfactory in service, and those which are unsatisfactory. Identify good detail design practices.

3) Review and assemble stress analysis methods which have proven satisfactory for ship detail design. Particularly consider fatigue analyses and allowable stresses, with recognition of environmental conditions. Prepare charts and graphs to assist the designer in stress analysis of details, where appropriate.

4) Assemble available data on fabrication man-hours for families of details. Indicate features of the details, which represent both good design practice and minimal fabrication costs.

5) Prepare a design guide, on ship details, covering at least the following aspects:-

a) Good detail design practice for each "family" of details

b) Poor detail design practice.

c) Recommended methods of stress analysis for details, including structural criteria

d) Representative fabrication man-hours, differentiating within each "family" of details, with indications of detail design practices which minimize fabrication manhours.

REFERENCES

1. Review of Ship Structural Details, by R. Glasfeld, D. Jordan, M. Kerr, Jr., and D. Zolle, SSC-266, 1977.
2. In-Service Performance of Structural Details, by C.R. Jordan and C.S. Cochran, SSC-272, 1978.
3. Further Survey of In-Service Performance of Structural Details, by C.R. Jordan and L.T. Knight, SSC-294, 1980.
4. Study of Fatigue Characterization of Fabricated Ship Details; Ship Structure Committee Project SR 1257, University of Illinois, July 1980.

MAN-HOURS

3000

REVIEW OF ACTIVE AND PENDING PROJECTS

This section of the report covers current projects funded with FY 1980 (or earlier) funds, others that have been continued with FY 1981 funds, and those which are anticipated to be supported with FY 1981 funds. These projects, listed in Table III, constitute the current program. The majority of projects are for one-year's duration; multiyear projects are funded incrementally on an annual basis.

Project descriptions, including the SR project number and title, the name of the principal investigator and his organization, where these have been determined, and the activation date and funding, where applicable, are provided. The appropriate SSC Long-Range Goal is also noted, and a very brief statement of the objective of each project is given. These are followed by a short description of the present status of the project.

This format does not permit a detailed or comprehensive description of individual projects; however, each project included will normally result in one or more SSC reports.

TABLE III -- REVIEW OF ACTIVE AND PENDING PROJECTS

PROJECT NO:	SR-1245
PROJECT TITLE:	REDUCTION OF SL-7 SCRATCH-GAGE DATA
INVESTIGATOR:	Mr. E. T. Booth
CONTRACTOR:	Teledyne Engineering Services, Waltham, MA
ACTIVATION DATE:	March 1977
CONTRACT FUNDING:	$88,511
SSC LONG-RANGE GOAL:	Response Criteria
CONTRACT NUMBER:	DOT-CG-61712-A & 844331-A

OBJECTIVE

The objective is to obtain and reduce two additional years of scratch-gage records from eight SL-7 containerships to usable form and to compare these data with electrical strain-gage data obtained aboard the SL-7 SEA-LAND McLEAN.

STATUS

Two-years of data have been obtained and are now being reduced for a final report.

All of the scratch gages have been removed from the ships and returned to the laboratory for calibration, repair and storage.

PROJECT NO:	SR-1256
PROJECT TITLE:	INVESTIGATION OF STEELS FOR IMPROVED WELDABILITY IN SHIP CONSTRUCTION
INVESTIGATOR:	Dr. B.G. Reisdorf
CONTRACTOR:	U.S. Steel Corporation, Monroeville, PA
ACTIVATION DATE:	September 29, 1978
CONTRACT FUNDING:	$204,796
SSC LONG-RANGE GOAL:	Fabrication Techniques
CONTRACT NUMBER:	DOT-CG-80588-A

OBJECTIVE

The objective of this multi-year study is to select the optimum materials and welding parameters to improve resistance to degradation of the heat-affected-zone (HAZ) properties in weldments made with high-deposition rate processes.

STATUS

Three production heats of steels and twenty laboratory heats have been tested to determine those compositions that show promise of developing good heat-affected-zone (HAZ) toughness. A calcium-treated, 0.08 percent vanadium steel with low residuals appears to have the best combination of HAZ toughness and base-plate strength and toughness. A detailed study of the microstructural features of the HAZ's and an analysis of the mechanisms responsible for good and poor performance in seven of these steels will soon be conducted.

PROJECT NO:	SR-1257
PROJECT TITLE:	FATIGUE CHARACTERIZATION OF FABRICATED SHIP DETAILS
INVESTIGATOR:	Prof. W.H. Munse
CONTRACTOR:	University of Illinois, Urbana, IL
ACTIVATION DATE:	November 30, 1978
CONTRACT FUNDING:	$95,016
SSC LONG-RANGE GOAL:	Materials Criteria
CONTRACT NUMBER:	DOT-CG-823899-A

OBJECTIVE

The objective of this multi-year study is to classify ship details in terms of their behavior and useful life under cyclic-loading conditions.

STATUS

Design criteria provides for, (a) the geometry of the members, connections, or details, (b) the nature of the stresses to which the details will be subjected, (c) the effect of the strength of the steel, (d) the level of reliability desired, and (e) the loading (as represented by a random loading factor) to which one expects the real structures to be subjected. Seven to eight hundred S-N curves have been assembled and mean fatigue strengths for many different fatigue details have been established. Five details lacking S-N curves have been selected for testing.

PROJECT NO:	SR-1259
PROJECT TITLE:	A LONG-RANGE RESEARCH PROGRAM IN SHIP STRUCTURES
INVESTIGATOR:	Mr. J.J. Hopkinson
CONTRACTOR:	Gibbs & Cox, Inc., Arlington, VA
ACTIVATION DATE:	January 31, 1979
CONTRACT FUNDING:	$226,320
SSC LONG-RANGE GOAL:	Advanced Concepts and Long-Range Planning
CONTRACT NUMBER:	DOT-CG-80371-A

OBJECTIVE

The objective of this multi-year study is to develop a marine structures planning document directed toward, but not limited to, the technical goals and charter of the Ship Structure Committee, and to forecast the research and development needs, based on a system of priorities, for the next 20 years.

STATUS

Two workshops have been completed and a draft of the final report is being reviewed. The preliminary results of the first workshop, developing 155 project suggestions with some duplications, provided considerable material for consideration in preparing recommendations for the FY 1982 Ship Structure Committee's research program.

PROJECT NO:	SR-1261
PROJECT TITLE:	HULL STRUCTURAL DAMPING DATA
INVESTIGATOR:	Mr. T.P. Carroll
CONTRACTOR:	Carroll Associates, Bethesda, MD
ACTIVATION DATE:	March 12, 1979
CONTRACT FUNDING:	$21,733
SSC LONG-RANGE GOAL:	Design Methods
CONTRACT NUMBER:	DOT-CG-824267-A

OBJECTIVE

The objective of this study is to collect and evaluate available structural damping data applicable to ship vibration analysis, and to recommend an experimental program, model or full scale, to expand and verify the design data.

STATUS

The draft final report has been reviewed and substantial revisions have been recommended.

PROJECT NO:	SR-1263
PROJECT TITLE:	SHIP STRUCTURAL DESIGN CONCEPTS - PART II
INVESTIGATOR:	Dr. J.H. Evans
CONTRACTOR:	J.H. Evans, Lexington, MA
ACTIVATION DATE:	March 1, 1978
CONTRACT FUNDING:	$27,000
SSC LONG-RANGE GOAL:	Design Methods
CONTRACT NUMBER:	DOT-CG-80358-A

OBJECTIVE

The objective of this two-year study is to prepare a supplementary monograph to the Ship Structural Design Concepts published in 1974.

STATUS

Chapters are being reviewed by a panel of the SNAME Hull Structure Committee. The Chapter titles are:

1. Shear Stresses Due to Bending,
2. Torsion,
3. Hull-deckhouse Interaction,
4. Principal Stresses (and Extent of Unreduced Scantlings),
5. Hull Girder Deflections and Stiffness,
6. Full-Scale Longitudinal Strength Experiments, and
7. Preliminary Choice of Framing Systems and Hull Girder Proportions (and Hull Synthesis in the Presence of Bending plus Shear).

PROJECT NO:	SR-1269
PROJECT TITLE:	INTERNAL CORROSION AND CORROSION CONTROL ALTERNATIVES
INVESTIGATOR:	Mr. C.R. Jordan
CONTRACTOR:	Newport News Shipbuilding and Drydock Company, Newport News, VA
ACTIVATION DATE:	January 14, 1980
CONTRACT FUNDING:	$50,850
SSC LONG-RANGE GOAL:	Materials Criteria
CONTRACT NUMBER:	DOT-CG-80-C-91291

OBJECTIVE

The objective of this project is to develop a method for making sensitivity studies of the relative life-cycle costs of corrosion control techniques--including combinations of increased scantlings, full or partial coatings, and anodes--to protect internal surfaces of ballast and cargo tanks in steel tankers as a means to rank corosion control systems.

STATUS

The final report is being written and shall contain:

a. Tables of corrosion-control conditions and corrosion-control performance.

b. Factors affecting corrosion and corrosion control.

c. Corrosion-control cost factors

d. Economic analysis

e. Sensitivity studies on a 40,000 DWT product tanker and a 285,000 DWT crude carrier.

f. Conclusions and recommendations

PROJECT NO:	SR-1270
PROJECT TITLE:	SURVEY OF EXPERIENCE USING REINFORCED CONCRETE IN FLOATING MARINE STRUCTURES
INVESTIGATOR:	Dr. O.H. Burnside
CONTRACTOR:	Southwest Research Institute, San Antonio, TX
ACTIVATION DATE:	November 26, 1979
CONTRACT FUNDING:	$34,530
SSC LONG-RANGE GOAL:	Advanced Concepts and Long-Range Planning
CONTRACT NUMBER:	DOT-CG-919837-A

OBJECTIVE

The objective of this project is to assess the state-of-the-art for reinforced concrete, including prestressed and conventionally reinforced concrete, applicable to floating marine structures.

STATUS

The final report will be delayed since the investigators plan to make personal contacts, while overseas on other company business, to obtain additional information. An overview of design procedures and current code requirements has been prepared to reflect the tone of the final report. In it, limit-state semi-probabilistic methods were used because they result in a structure whose safety can be more accurately defined.

PROJECT NO:	SR-1271
PROJECT TITLE:	PRESSURE DISTRIBUTION MODEL TESTS IN WAVES
INVESTIGATOR:	Prof. A.W. Troesch
CONTRACTOR:	Univ. of Michigan, Ann Arbor, MI
ACTIVATION DATE:	September 25, 1979
CONTRACT FUNDING:	$60,063
SSC LONG-RANGE GOAL:	Response Criteria
CONTRACT NUMBER:	DOT-CG-913367-A

OBJECTIVE

The objective of the project is to conduct model tests to measure hull surface pressures and compare them with calculated pressures.

STATUS

All of the model tests have been completed. The American Bureau of Shipping has been exercising their SHIPMOTION computer program to perform the calculations. These results will be compared with the model test data and a final report will be written.

PROJECT NO:	SR-1272
PROJECT TITLE:	COMPUTER-AIDED PROCEDURE FOR CALCULATING GROUNDED SHIP RESPONSES
INVESTIGATOR:	Unknown
CONTRACTOR:	Unknown
ACTIVATION DATE:	Unknown
CONTRACT FUNDING:	2000 Man-hours
SSC LONG-RANGE GOAL:	Advanced Concepts and Long-Range Planning
CONTRACT NUMBER:	To be assigned

OBJECTIVE

The objective of this project is to design the logic for a computer program which will aid in the assessment of damage, stability and survivability of grounded tank ships, including LNG carriers.

STATUS

This project is now being reconsidered in the list of FY 1982 projects as SRC priority 82-4.

PROJECT NO:	SR-1275
PROJECT TITLE:	FULL-SCALE PRESSURE DISTRIBUTION MEASUREMENTS OF M/V S.J. CORT
INVESTIGATOR:	Mr. A.L. Dinsenbacher
CONTRACTOR:	David Taylor Naval Ship Research and Development Center, Carderock, MD
ACTIVATION DATE:	December 19, 1978
CONTRACT FUNDING:	$76,700
SSC LONG-RANGE GOAL:	Response Criteria
CONTRACT NUMBER:	N6519779PO90714

OBJECTIVE

The objective of this project is to measure full-scale pressure distributions to validate pressure prediction analysis methods.

STATUS

Full-scale pressure measurements from the M/V S J CORT are now being compared with the American Bureau of Ships' SHIPMOTION computer results. Preliminary indications are that the correlations are quite favorable for some gauges but not for others. The amplitudes differ, but the phasing is the same. A final report is being prepared.

PROJECT NO:	SR-1276
PROJECT TITLE:	LONG-TERM CORROSION FATIGUE OF WELDED MARINE STEELS
INVESTIGATOR:	Dr. O.H. Burnside
CONTRACTOR:	Southwest Research Institute, San Antonio, TX
ACTIVATION DATE:	September 29, 1980
CONTRACT FUNDING:	$144,810
SCC LONG-RANGE GOAL:	Materials Criteria
CONTRACT NUMBER:	DTCG23-80-C-20028

OBJECTIVE

The objective of the research is to define and evaluate currently available technology for assessing the long-life corrosion fatigue behavior of welded joints in sea water; and to develop a plan for long-term future efforts, if required.

STATUS

Data are being collected on long-term corrosion parameters applicable to welded joints in seawater. Two basic approaches are being pursued to identify candidate design and analysis procedures to predict fatigue life of marine structures--a deterministic approach, where worst-case combinations of environment, structural loading, flaw size, and material affinity to corrosion will be used, and--a probabilistic approach, where variables will be assigned probability distributions functions.

PROJECT NO:	SR-1277
PROJECT TITLE:	ADVANCED METHOD FOR SHIP-MOTION AND WAVE-LOAD PREDICTIONS
INVESTIGATOR:	Mr. J.C. Oliver
CONTRACTOR:	Giannotti and Associates, Inc., Annapolis, MD
ACTIVATION DATE:	September 29, 1980
CONTRACT FUNDING:	$99,534
SSC LONG-RANGE GOAL:	Loads Criteria
CONTRACT NUMBER:	DTCG23-80-C-20032

OBJECTIVE

The objective of the study is to develop a method and appropriate computer program for predicting ship motions and distributed wave loads, taking into account the hull form shape above and below the still waterline, including the three-dimensional hydrodynamic coefficients.

STATUS

A review and evaluation of ship motions and load predictions, numerical hydrodynamics and computational methods has begun in order to select a feasible approach for developing a mathematical model. The criteria for the selection will be based on accuracy, rigorousness, generality, ease of input and operation, computational costs, and numerical stability and errors. The impact of assumptions and simplifications will also be evaluated throughout the development of the model so that a balance can be achieved between rigor and expedience.

PROJECT NO:	SR-1279
PROJECT TITLE:	SL-7 PROGRAM SUMMARY, CONCLUSIONS AND RECOMMENDATIONS
INVESTIGATOR:	Mr. W.A. Wood
CONTRACTOR:	Giannotti and Associates, Inc., Annapolis, MD.
ACTIVATION DATE:	August 14, 1980
CONTRACT FUNDING:	$25,220
SSC LONG-RANGE GOAL:	Response Criteria
CONTRACT NUMBER:	DTCG-23-80-C-20025

OBJECTIVE

The objective of the study is to review and evaluate the plans, procedures, results and accomplishments of the SL-7 program.

STATUS

A review and assessment of all SL-7 research reports has been completed. An evaluation of the program with respect to measurement and prediction of ship motions, loads, stresses and methods of statistical evaluation of the data has also been prepared. To complete the project, recommendations and a plan outline for further analysis of the data for future applications are being prepared.

PROJECT NO:	SR-1280
PROJECT TITLE:	ANALYSIS AND ASSESSMENT OF MAJOR UNCERTAINTIES IN SHIP HULL DESIGN
INVESTIGATOR:	Unknown
CONTRACTOR:	Unknown
ACTIVATION DATE:	Unknown
CONTRACT FUNDING:	1000 man-hours
SSC LONG-RANGE GOAL:	Determination of Failure Criteria (Reliability)
CONTRACT NUMBER:	DTCG 23-80-R-20029

OBJECTIVE

The objective of the study is to identify the major sources of uncertainties underlying the design of ship hull structures.

STATUS

Proposals have been evaluated and contract negotiations are underway.

PROJECT NO:	SR-1281
PROJECT TITLE:	SHIP STRUCTURES LOADING IN EXTREME WAVES
INVESTIGATOR:	Unknown
CONTRACTOR:	Unknown
ACTIVATION DATE:	Unknown
CONTRACT FUNDING:	1000 man-hours
SSC LONG-RANGE GOAL:	Loads Criteria
CONTRACT NUMBER:	DTCG 23-81-R-20007

OBJECTIVE

The objective of the study is to examine the probability of a ship encountering some kinds of extreme waves and to understand the significance of this in ship structural design.

STATUS

New proposals have been requested by the U.S. Coast Guard.

PROJECT NO:	SR-1282
PROJECT TITLE:	IN-SERVICE STILL-WATER BENDING MOMENT DETERMINATION
INVESTIGATOR:	Unknown
CONTRACTOR:	Unknown
ACTIVATION DATE:	Unknown
CONTRACT FUNDING:	1000 man-hours
SSC LONG-RANGE GOAL:	Loads Criteria
CONTRACT NUMBER:	DTCG 23-80-R-20034

OBJECTIVE

The objective of the study is to develop a plan to obtain in-service still-water loading data.

STATUS

A proposal has been evaluated and contract negotiations are underway.

PROJECT NO: SR-1283
PROJECT TITLE: PERFORMANCE OF UNDERWATER WELDMENTS
INVESTIGATOR: Unknown
CONTRACTOR: Unknown
ACTIVATION DATE: Unknown
CONTRACT FUNDING: 4500 man-hours (Two-year project)
SSC LONG-RANGE GOAL: Fabrication Techniques
CONTRACT NUMBER: DTCG-23-81-R-20020

OBJECTIVE

The objectives of the proposed research are to gather data on the mechanical properties on wet and wet-backed underwater weldments and to provide guidelines relating these properties to design performance.

STATUS

A Request for Proposals has been issued.

PROJECT NO: SR-1284
PROJECT TITLE: LIQUID SLOSH LOADING IN CARGO TANKS
INVESTIGATOR: Unknown
CONTRACTOR: Unknown
ACTIVATION DATE: Unknown
CONTRACT FUNDING: 3500 man-hours (Two-year project)
SSC LONG-RANGE GOAL: Loads Criteria
CONTRACT NUMBER: DTCG-23-81-R-20024

OBJECTIVE

The objective of this study is to determine sloshing loads, for liquids of specific gravities ranging from 0.4 to 1.8 and typical enroute service viscosities, on the boundaries, swash bulkheads and internal framing of partially filled tanks of various proportions.

STATUS

A Request for Proposals has been issued.

PROJECT NO:	SR-1285
PROJECT TITLE:	DETERMINATION OF THE RANGE OF SHIPBOARD STRAIN RATES
INVESTIGATOR:	Unknown
CONTRACTOR:	Unknown
ACTIVATION DATE:	Unknown
CONTRACT FUNDING:	1000 man-hours
SSC LONG-RANGE GOAL:	Response Criteria
CONTRACT NUMBER:	DTCG-23-81-R-20028

OBJECTIVE

The objective of this project is to develop a test program to obtain representative strain rates in ship hull structures.

STATUS

A Request for Proposals has been issued.

PROJECT NO: SR-1286
PROJECT TITLE: FILLET WELD STRENGTH PARAMETERS FOR SHIPBUILDING
INVESTIGATOR: Unknown
CONTRACTOR: Unknown
ACTIVATION DATE: Unknown
CONTRACT FUNDING: 1500 man-hours
SSC LONG-RANGE GOAL: Design Methods
CONTRACT NUMBER: DTCG-23-81-R-20030

OBJECTIVE

The objective of this project is to discover areas in the ship where fillet weld sizes may be safely reduced below current practices and to estimate the saving in construction cost from such reductions.

STATUS

A Request for Proposals has been issued.

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PROJECT NO:	SR-1287
PROJECT TITLE:	JOINT OCCURRENCE OF ENVIRONMENTAL DISTURBANCES
INVESTIGATOR:	Unknown
CONTRACTOR:	Unknown
ACTIVATION DATE:	Unknown
CONTRACT FUNDING:	2500 man-hours
SSC LONG-RANGE GOAL:	Loads Criteria
CONTRACT NUMBER:	Unknown

OBJECTIVE

The objective is to develop a method and a representative data bank, useful for design, that identifies the simulataneous occurrence of winds and directional wave spectra.

STATUS

A proposal request has been prepared.

PROJECT NO: SR-1288
PROJECT TITLE: FRACTURE CONTROL FOR FIXED OFFSHORE STRUCTURES
INVESTIGATOR: Unknown
CONTRACTOR: Unknown
ACTIVATION DATE: Unknown
CONTRACT FUNDING: 1000 man-hours
SSC LONG-RANGE GOAL: Materials Criteria
CONTRACT NUMBER: Unknown

OBJECTIVE

The objective of this study is to examine critically the technology and practices that constitute the fracture-control plans used by designeers, builders and operators of fixed offshore structures.

STATUS

A proposal request has been prepared.

PROJECT NO:	SR-1289
PROJECT TITLE:	STRUCTURAL INSPECTION GUIDELINES
INVESTIGATOR:	Unknown
CONTRACTOR:	Unknown
ACTIVATION DATE:	Unknown
CONTRACT FUNDING:	1500 man-hours
SSC LONG-RANGE GOAL:	Determination of Failure Criteria (Reliability)
CONTRACT NUMBER:	Unknown

OBJECTIVE

The objective of this study is to develop a guide that will set forth a coherent philosophy toward structural inspection for use of technical people involved in designing, building, accepting, and operating ships.

STATUS

A proposal request has been prepared.

REVIEW OF COMPLETED PROJECTS

The projects completed since the last annual report are listed below. Project descriptions, similar to those for the current program, follow. Reports from these projects have either been published or are presently in the publication process and the final SSC reports can be expected in the near future.

SR-1238, "Fracture-Toughness Characterization of Ship Steel Weldments"

SR-1245, "Reduction of SL-7 Scratch-Gage Data"

SR-1254, "Fatigue Considerations in View of Measured Load Spectra"

SR-1266, "Criteria for Hull/Machinery Rigidity Compatibility"

SR-1267, "Ice Strengthening Criteria for Ships"

SR-1268, "Evaluation of SL-7 Scratch-Gage Data"

SR-1274, "Computer-Aided, Preliminary Ship Structural Design"

The following two projects were not undertaken for the reasons cited in the project descriptions:

SR-1273, "Computer-Aided Procedure for Drydocking Calculations"

SR-1278, "Steels for Marine Structures in Arctic Environments"

PROJECT NO.:	[illegible]
PROJECT TITLE:	[illegible]
INVESTIGATOR:	[illegible]
CONTRACTOR:	U.S. [illegible]
ACTIVATION DATE:	[illegible]
CONTRACT [illegible]:	[illegible]
SSC LONG-RANGE GOAL:	[illegible]
CONTRACT NUMBER:	DOT-CG-[illegible]

OBJECTIVE

The objective is to determine the relevance of the Charpy V-notch energy criteria currently employed in assessing the behavior of steel weldments.

RESULTS

The Charpy V-notch (CVN) specimen is the best "quality-control" type of specimen to use for assessing fracture toughness in ship-steel weldments. Data show that CVN tests at different locations in the weldment are necessary and should be continued as a requirement. The 5/8-inch-thick dynamic tear test was also examined but the data indicate that the test specimen samples too many regions of the weldment at one time and is, therefore, not sufficiently discriminatory to be recommended for use in qualifying the toughness behavior of the heat-affected zone in weldments.

[illegible]

OBJECTIVE

The objective of this study is to assess the [illegible] extent of retardation effects under fatigue loading spectra.

RESULTS

The data show a) that crack retardation does result from the loading experienced by ships, b) that crack-growth predicted from a conventional fracture-mechanics approach is faster than that actually observed experimentally, and c) that high-frequency, low-amplitude components of the loading spectrum (resonant "whipping" [illegible] vibrations caused by impulsive loading) have no significant effect on crack-growth rate.

PROJECT NO.:	[illegible]
PROJECT TITLE:	[illegible]
INVESTIGATOR:	Prof. [illegible]
CONTRACTOR:	Massachusetts Institute of Technology, Cambridge, MA
ACTIVATION DATE:	September 2[illegible], 197[illegible]
CONTRACT FUNDING:	$[illegible],000
SSC LONG-RANGE GOAL:	Response Criteria
CONTRACT NUMBER:	DOT-CG-[illegible]-A

OBJECTIVE

The objective of this study is to develop criteria for compatability in rigidity of hull and main-propulsion machinery.

RESULTS

Proposed limits for the deflections of machinery support points have been developed. Integration of machinery foundations with basic hull structure, whereby bulkheads, both transverse and longitudinal, as well as deck and shaft alley structure may be utilized to improve overall stiffness and particularly to distribute thrust forces to the hull on as wide an area as possible is recommended. These items are coupled with suggested methods and techniques of structural analysis and design which can assist the designer.

PROJECT NO: SR-1267
PROJECT TITLE: ICE STRENGTHENING CRITERIA FOR SHIPS
INVESTIGATOR: Dr. R.P. Voelker
CONTRACTOR: ARCTEC, Incorporated, Columbia, MD
ACTIVATION DATE: August 20, 1979
CONTRACT FUNDING: $56,223
SSC LONG-RANGE GOAL: Loads Criteria
CONTRACT NUMBER: DOT-CG-904937-A

OBJECTIVE

The objective of this study is to develop a basis for rational selection of ice strengthening criteria for vessels.

RESULTS

A comparison of different ice strengthening criteria on the basis of weight and relative costs was conducted, as well as different materials and fabrication techniques used for ice strengthening. Deficiencies in current procedures have been identified and a rational procedure for selecting appropriate ice strengthening criteria is now available.

PROJECT NO: SR-1268
PROJECT TITLE: EVALUATION OF SL-7 SCRATCH-GAGE DATA
INVESTIGATOR: Dr. P.R. Van Mater, Jr.
CONTRACTOR: Giannotti and Associates, Inc., Annapolis, MD
ACTIVATION DATE: September 26, 1979
CONTRACT FUNDING: $21,097
SSC LONG-RANGE GOAL: Response Criteria
CONTRACT NUMBER: DOT-CG-920932-A

OBJECTIVE

The objective of this study is to establish a measure for judging when sufficient scratch-gage data have been obtained so that the gages can be removed for placement aboard other ships.

RESULTS

Several statistical models were found to describe the scratch-gage data well enough to be used as a basis for statistical inference beyond the range of measured values. It was concluded that two of the models can be used to infer lifetime extreme values for the SL-7 class or similar ship. Therefore, the scratch gages can now be removed from the SL-7's and used for studies of long-term mean-stress variations and ship response in extreme environmental conditions. However, further use of the gages for studies related to long-term distribution of ship response and loads is not recommended.

PROJECT NO:	SR-1274
PROJECT TITLE:	COMPUTER-AIDED, PRELIMINARY SHIP STRUCTURAL DESIGN
INVESTIGATOR:	Dr. A. E. Mansour
CONTRACTOR:	Mansour Engineering, Inc., Berkeley, CA
ACTIVATION DATE:	September 18, 1979
CONTRACT FUNDING:	$23,560
SSC LONG-RANGE GOAL:	Design Methods
CONTRACT NUMBER:	DOT-CG-919802-A

OBJECTIVE

The objective of this project is to assess the state-of-the-art of computer-aided design systems in both ship and non-ship areas for use in preliminary ship structural design.

RESULTS

The elements of an "ideal" program suitable for the preliminary structural design of ships are identified and used in the evaluation of available software. Suitable programs were then selected for the various typical aspects of ship preliminary structural design. Existing software that approaches the "ideal" in the marine field for preliminary structural design of ships are HULDA from Det norske Veritas and INDETS from the Norwegian Institute of Technology.

PROJECT NO:	SR-1273
PROJECT TITLE:	COMPUTER-AIDED PROCEDURE FOR DRYDOCKING CALCULATIONS
INVESTIGATOR:	Unknown
CONTRACTOR:	Unknown
ACTIVATION DATE:	Unknown
CONTRACT FUNDING:	2000 Man-hours
SSC LONG-RANGE GOAL:	Design Methods
CONTRACT NUMBER:	To be assigned

OBJECTIVE

The objective of this project is to develop a computer program to calculate individual drydock block loads, primary hull-bending loads upon drydocking and the stresses in the pontoon deck of the floating dry dock.

RESULTS

Because of a recent drydocking problem, the U.S. Navy has opted to initiate this project on its own.

PROJECT NO:	SR-1278
PROJECT TITLE:	STEELS FOR MARINE STRUCTURES IN ARCTIC ENVIRONMENTS
INVESTIGATOR:	Unknown
CONTRACTOR:	Unknown
ACTIVATION DATE:	Unknown
CONTRACT FUNDING:	1500 man-hours
SSC LONG-RANGE GOAL:	Materials Criteria
CONTRACT NUMBER:	DTCG-23-80-R-20003

OBJECTIVE

The objective of the study is to evaluate research reports and other literature on material selection, fabrication techniques, and material reliablity on non-marine cold-weather applications to determine the usefulness of these materials and techniques for marine structures in an Arctic environment.

STATUS

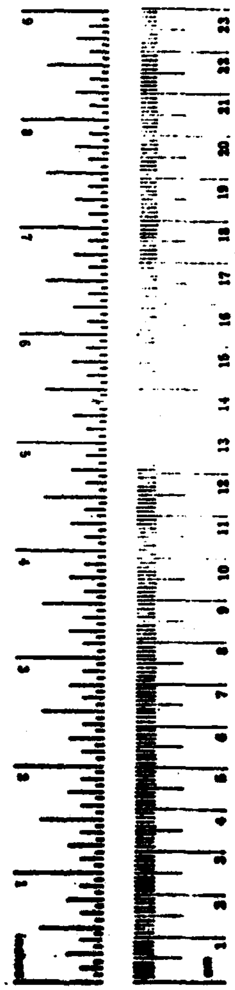
The U.S. Geological Survey, a sponsoring agency of the Ship Structure Committee, desired to undertake this research effort under their own auspices. Therefore, the Coast Guard has cancelled the Request for Proposal.

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

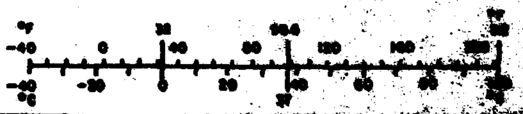
Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in ≡ 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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7. Author(s)	8. Performing Organization Report No.
9. Performing Organization Name and Address: SHIP RESEARCH COMMITTEE, NATIONAL ACADEMY OF SCIENCES, 2101 CONSTITUTION AVENUE, WASHINGTON, D.C. 20418	10. Work Unit No. (TRAIS)
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12. Sponsoring Agency Name and Address: COMMANDANT (G-DST), U.S. COAST GUARD HEADQUARTERS, OFFICE OF RESEARCH AND DEVELOPMENT, WASHINGTON, D.C. 20593	13. Type of Report and Period Covered: FINAL REPORT
	14. Sponsoring Agency Code: G-DST-2

15. Supplementary Notes

16. Abstract

The Ship Research Committee (SRC) of the National Research Council provides technical services covering program recommendations, proposal evaluations, and project advice to the interagency Ship Structure Committee (SSC), composed of representatives from the U.S. Coast Guard, the Naval Sea Systems Command, the Military Sealift Command, the Maritime Administration, the American Bureau of Shipping, and the U.S. Geological Survey. This arrangement requires continuing interaction among the SRC, the SSC, the contracting agency, and the project investigators to assure an effective program to improve marine structures through an extension of knowledge of materials, fabrication methods, static and dynamic loading and response, and methods of analysis and design. This report contains the Ship Research Committee's recommended research program for five years, FY 1981-1984 with specific prospectuses for FY 1982. Also included is a brief review of 24 active and 5 recently completed projects.

17. Key Words	18. Distribution Statement
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Under the terms of its Congressional charter, the Academy is also called upon to act as an official - yet independent - advisor to the Federal Government in any matter of science and technology. This provision accounts for the close ties that have always existed between the Academy and the Government, although the Academy is not a governmental agency and its activities are not limited to those on behalf of the Government.

THE NATIONAL ACADEMY OF ENGINEERING was established on December 5, 1964. On that date, the Council of the National Academy of Sciences, under the Authority of its Act of Incorporation, adopted Articles of Organization bringing the National Academy of Engineering into being, independent and autonomous in its organization and the election of its members, and closely coordinated with the National Academy of Sciences in its advisory activities. The two Academies join in the furtherance of science and engineering and share the responsibility of advising the Federal Government, upon request, on any subject of science or technology.

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Supported by private and public contributions, grants, and contracts, and voluntary contributions of time and effort by several thousand of the nation's leading scientists and engineers, the Academies and their Research Council thus work to serve the national interest, to foster the sound development of science and engineering, and to promote their effective application for the benefit of society.

THE COMMISSION ON SOCIOTECHNICAL SYSTEMS is one of the major components of the National Research Council and has general responsibility for and cognizance over those program areas concerned with physical, technological, and industrial systems that are or may be deployed in the public or private sector to serve societal needs.

THE MARITIME TRANSPORTATION RESEARCH BOARD is an operating unit of the Commission on Sociotechnical Systems of the National Research Council. The role of MTRB is to stimulate research, and advise on applications, in the broad field of maritime transportation. The Board provides guidance within the NRC for maritime transportation and marine transportation systems, including impact of such systems on the economy and society; improvement of ships, cargo handling, ports and marine facilities; education, training and working conditions of marine personnel; and relationship of elements of the marine transportation system to other transportation, economic, and social systems. The role of the merchant marine in national defense is a vital part of the Board's program.

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